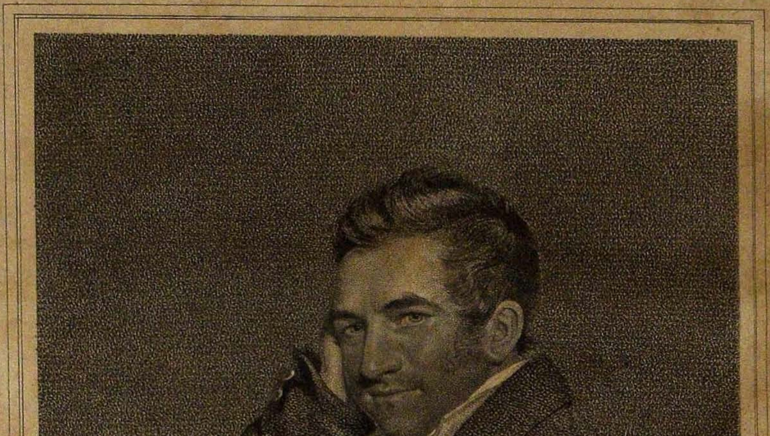

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AN

INTRODUCTION

TO

ENTOMOLOGY:

OR

ELEMENTS

OF THE

NATURAL HISTORY OF INSECTS:

WITH PLATES.

BY WILLIAM KIRBY, M.A. F.R. AND L.S.

RECTOR OF BARHAM,

AND

WILLIAM SPENCE, ESQ. F.L.S.

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AN

INTRODUCTION

TO

ENTOMOLOGY.

LETTER XVI.

SOCIETIES OF INSECTS.

IMPERFECT SOCIETIES.

I SEE already, and I see it with pleasure, that you will not content yourself with being a mere collector of insects. To possess a cabinet well stored, and to know by what name each described individual which it contains should be distinguished, will not satisfy the love that is already grown strong in you for my favourite pursuit; and you now anticipate with a laudable eagerness, the discoveries that you may make respecting the history and economy of this most interesting department of the works of our Creator. I hail with joy this intention to emulate the bright example, and to tread in the hallowed steps of Swammerdam, Leeuwenhoek, Redi, Malpighi, Vallisnieri, Ray, Lister, Reaumur, De Geer, Lyonet, Bonnet, the Hubers, &c.; and I am confident that

a man of your abilities, discernment, and observation will contribute, in no small degree, to the treasures already poured into the general fund by these your illustrious predecessors.

I feel not a little flattered when you inform me that the details contained in my late letters relative to this subject, have stimulated you to this noble resolution.—Assure yourself, I shall think no labour lost, that has been the means of winning over to the science I love, the exertions of a mind like yours.

But if the facts already related, however extraordinary, have had power to produce such an effect upon you, what will be the momentum, when I lay before you more at large, as I next purpose, the most striking particulars of the proceedings of insects in society, and show the almost incredibly wonderful results of the combined instincts and labours of these minute beings? In comparison with these, all that is the fruit of solitary efforts, though some of them sufficiently marvellous, appear trifling and insignificant: as the works of man himself, when they are the produce of the industry and genius of only one, or a few individuals, though they might be regarded with admiration by a being who had seen nothing similar before, yet when contrasted with those to which the union of these qualities in large bodies has given birth, sink into nothing, and seem unworthy of attention. Who would think a hut extraordinary by the side of a stately palace, or a small village when in the vicinity of a populous and magnificent city?

Insects in society may be viewed under several lights, and their associations are for various purposes and of different durations.

There are societies the object of which is mutual defence; while that of others is the propagation of the species. Some form marauding parties, and associate for prey and plunder;—others meet, as it should seem, under certain circumstances, merely for the sake of company;—again, others are brought together by accidental causes, and disperse when these cease to operate;—and finally, others, which may be said to form proper societies, are associated for the nurture of their young, and, by the union of their labours and instincts, for mutual society, help, and comfort, in erecting or repairing their common habitation, in collecting provisions, and in defending their fortress when attacked.

With respect to the *duration* of the societies of insects, some last only during their first or larva state; and are occasionally even restricted to its earliest period;—some again only associate in their perfect or imago state; while with others, the *proper* societies for instance, the association is for life. But if I divide societies of insects into perfect and imperfect, it will, I think, enable me to give you a clearer and better view of the subject. By *perfect* societies I mean those that are associated in all their states, live in a common habitation, and unite their labours to promote a common object;—and by *imperfect* societies, those that are either associated during part of their existence only, or else do not dwell in a common habitation, nor unite their labours to promote a common object. In the present letter I shall confine myself to giving you some account of *imperfect* societies.

Imperfect societies may be considered as of five descriptions:—associations for the sake of company only

—associations of males during the season for pairing—associations formed for the purpose of travelling or emigrating together—associations for feeding together—and associations that undertake some common work.

The first of these associations consists chiefly of insects in their perfect state. The little beetles called whirlwigs (*Gyrinus*, L.),—which may be seen clustering in groups under warm banks in every river and every pool, and wheeling round and round with great velocity; at your approach dispersing and diving under water, but as soon as you retire resuming their accustomed movements,—seem to be under the influence of the social principle, and to form their assemblies for no other purpose but to enjoy together, in the sunbeam, the mazy dance. Impelled by the same feeling, in the very depth of winter, even when the earth is covered with snow, the tribes of *Tipulidæ* (usually, but improperly, called gnats) assemble in sheltered situations at midday, when the sun shines, and form themselves into choirs, that alternately rise and fall with rapid evolutions[a]. To see these little aëry beings apparently so full of joy and life, and feeling the entire force of the social principle in that dreary season, when the whole animal creation appears to suffer, and the rest of the insect tribes are torpid, always conveys to my mind the most agreeable sensations. These little creatures may always be seen at all seasons amusing themselves with these choral dances; which Mr. Wordsworth, in a late poem[b], has alluded to in the following beautiful lines:

[a] See also Markwick in White's *Nat. Hist.* ii. 256.

[b] *The Excursion.*

"Nor wanting here to entertain the thought,
Creatures that in communities exist,
Less, as might seem, for general guardianship
Or through dependance upon mutual aid,
Than by participation of delight,
And a strict love of fellowship combined.
What other spirit can it be that prompts
The gilded summer flies to mix and weave
Their sports together in the solar beam,
Or in the gloom and twilight hum their joy?"

Another association is that of males during the season of pairing. Of this nature seems to be that of the cockchafer and fernchafer (*Melolontha vulgaris* and *solstitialis*, F.), which, at certain periods of the year and hours of the day, hover over the summits of the trees and hedges like swarms of bees, affording, when they alight on the ground, a grateful food to cats, pigs, and poultry. The males of another root-devouring beetle (*Hoplia argentea*, F.) assemble by myriads before noon in the meadows, when in these infinite hosts you will not find even one female[a]. After noon the congregation is dissolved, and not a single individual is to be seen in the air[b]: while those of *Melolontha vulgaris* and *solstitialis* are on the wing only in the evening.

At the same time of the day some of the short-lived Ephemeræ assemble in numerous troops, and keep rising and falling alternately in the air, so as to exhibit a very amusing scene. Many of these also are males. They continue this dance from about an hour before sun-set, till the dew becomes too heavy or too cold for them. In the beginning of September, for two successive years,

[a] The females (*Scarabæus argenteus*, Marsh.) have red legs, and the males (*Scarabæus pulverulentus*, Marsh.) black.

[b] Kirby in *Linn. Trans.* v. 256.

I was so fortunate as to witness a spectacle of this kind, which afforded me a more sublime gratification than any work or exhibition of art has power to communicate.—The first was in 1811:—taking an evening walk near my house, when the sun declining fast towards the horizon shone forth without a cloud, the whole atmosphere over and near the stream swarmed with infinite myriads of Ephemeræ and little gnats of the genus *Chironomus*, Latr., which in the sun-beam appeared as numerous and more lucid than the drops of rain, as if the heavens were showering down brilliant gems.—Afterwards, in the following year, one Sunday, a little before sun-set, I was enjoying a stroll with a friend at a greater distance from the river, when in a field by the road-side the same pleasing scene was renewed, but in a style of still greater magnificence; for, from some cause in the atmosphere, the insects at a distance looked much larger than they really were. The choral dances consisted principally of Ephemeræ, but there were also some of Chironomi; the former, however, being most conspicuous, attracted our chief attention—alternately rising and falling, in the full beam they appeared so transparent and glorious, that they scarcely resembled any thing material—they reminded us of angels and glorified spirits drinking life and joy in the effulgence of the Divine favour[a]. The bard of Twickenham, from the terms in which his beautiful description of his sylphs is conceived in *The Rape of the Lock*, seems to have witnessed the pleasing scene here described;

[a] The authors of this work were the witnesses of the magnificent scene here described. It was on the second of September. The first was on the ninth of that month.

"Some to the sun their insect wings unfold,
Waft on the breeze, or sink in clouds of gold;
Transparent forms, too fine for mortal sight,
Their fluid bodies half dissolv'd in light;
Loose to the wind their airy garments flew,
Thin glitterring textures of the filmy dew,
Dipt in the richest tincture of the skies,
Where light disports in ever mingling dyes,
While every beam new transient colours flings,
Colours that change whene'er they wave their wings."

I wish you may have the good fortune next year to be a spectator of this all but celestial dance. In the mean time, in May and June, their season of love, you may often receive much gratification from observing the motions of a countless host of little black flies of the genus *Empis*, (*E. maura*, F.) which at this period of the year assemble to wheel in aëry circles over stagnant waters, with a rush resembling that of a hasty shower driven by the wind.

The next description of insect associations is of those that congregate for the purpose of travelling or emigrating together. De Geer has given an account of the larvæ of certain gnats (*Tipulæ*, L.) which assemble in considerable numbers for this purpose, so as to form a band of a finger's breadth, and of from one to two yards in length. And, what is remarkable, while upon their march, which is very slow, they adhere to each other by a kind of glutinous secretion; but when disturbed they separate without difficulty[a]. Kuhn mentions another of the *Tipulidæ* (from the antennæ in his figure, which is very indifferent, it should seem a species of agaric-gnat (*Mycetophila*), the larvæ of which live in society and

[a] De Geer, vi. 338.

emigrate in files, like the caterpillar of the procession-moth. First goes one, next follow two, then three, &c., so as to exhibit a serpentine appearance, probably from their simultaneous undulating motion and the continuity of the files; whence the common people in Germany call them (or rather the file when on march) *heerwurm*, and view them with great dread, regarding them as ominous of war. These larvæ are apodes, white, sub-transparent, with black heads[a].—But of insect emigrants none are more celebrated than the locusts, which, when arrived at their perfect state, assemble as before related, in such numbers, as in their flight to intercept the sun-beams, and to darken whole countries; passing from one region to another, and laying waste kingdom after kingdom:—but upon these I have already said much, and shall have occasion again to enlarge.—The same tendency to shift their quarters has been observed in our little indigenous devourers, the Aphides. Mr. White tells us, that about three o'clock in the afternoon of the first of August 1785, the people of the village of Selborne were surprised by a shower of Aphides or smother-flies, which fell in those parts. Those that walked in the street at that juncture found themselves covered with these insects, which settled also upon the hedges and in the gardens, blackening all the vegetables where they alighted. His annuals were discoloured by them, and the stalks of a bed of onions quite coated over for six days after. These armies, he observes, were then, no doubt, in a state of emigration, and shifting their quarters; and might have come from the great hop-plantations of Kent or Sussex, the wind being all that day in

[a] *Naturforsch.* xvii. 226.

the east. They were observed at the same time in great clouds about Farnham, and all along the vale from Farnham to Alton[a]. A similar emigration of these flies I once witnessed, to my great annoyance, when travelling later in the year, in the Isle of Ely. The air was so full of them, that they were incessantly flying into my eyes, nostrils, &c.; and my clothes were covered by them. And in 1814, in the autumn, the Aphides were so abundant for a few days in the vicinity of Ipswich, as to be noticed with surprise by the most incurious observers.

As the locust-eating thrush (*Turdus gryllivorus*, L.) accompanies the locusts, so the Coccinellæ seem to pursue the Aphides; for I know no other reason to assign for the vast number that are sometimes, especially in the autumn, to be met with on the sea-coast or the banks of large rivers. Many years ago, those of the Humber were so thickly strewed with the common Lady-bird (*C. septempunctata*, L.), that it was difficult to avoid treading upon them. Some years afterwards I noticed a mixture of species, collected in vast numbers, on the sand-hills on the sea-shore, at the north-west extremity of Norfolk. My friend the Rev. Peter Lathbury made long since a similar observation at Orford, on the Suffolk coast; and about five or six years ago they covered the cliffs, as I have before remarked[b], of all the watering-places on the Kentish and Sussex coasts, to the no small alarm of the superstitious, who thought them forerunners of some direful evil. These last probably emigrated with the Aphides from the hop-grounds. Whether the latter and their devourers cross the sea has not been ascer-

[a] *Nat. Hist.* ii. 101.

[b] Vol. I. 4th Ed. 263.

tained; that the Coccinellæ attempt it, is evident from their alighting upon ships at sea, as I have witnessed myself.—This appears clearly to have been the case with another emigrating insect, the saw-fly (*Tenthredo*) of the turnip (which, though so mischievous, appears never to have been described; it is nearly related to *T. Centifoliæ*, Panz.)[a]. It is the general opinion in Norfolk, Mr. Marshall informs us[b], that these insects come from over sea. A farmer declared he saw them arrive in clouds so as to darken the air; the fishermen asserted that they had repeatedly seen flights of them pass over their heads when they were at a distance from land; and on the beach and cliffs they were in such quantities, that they might have been taken up by shovels-full. Three miles in-land they were described as resembling swarms of bees. This was in August 1782. Unentomological observers, such as farmers and fishermen, might easily mistake one kind of insect for another; but supposing them correct, the swarms in question might perhaps have passed from Lincolnshire to Norfolk.—Meinecken tells us, that he once saw in a village in Anhalt, on a clear day, about four in the afternoon, such a cloud of dragon-flies (*Libellulæ*, L.) as almost concealed the sun, and not a little alarmed the villagers, under the idea that they were locusts[c]; several instances are given by Rösel of similar clouds of these insects having been seen in Silesia and other districts[d]; and Mr. Woolnough of Hollesley in Suffolk, a most attentive observer of nature, once witnessed such an army of the smaller dragon-flies (*Agrion*, F.) flying in-land from the sea, as to cast a slight shadow

[a] *Fn. Germ. Init.* xlix. 18.
[b] *Philos. Trans.* lxxiii. 217.
[c] *Naturforsch.* vi. 110.
[d] ii. 135.

over a field of four acres as they passed.—Professor Walch states, that one night about eleven o'clock, sitting in his study, his attention was attracted by what seemed the pelting of hail against his window, which surprising him by its long continuance, he opened the window, and found the noise was occasioned by a flight of the froth frog-hopper (*Cicada spumaria*, L.), which entered the room in such numbers as to cover the table. From this circumstance and the continuance of the pelting, which lasted at least half an hour, an idea may be formed of the vast host of this insect passing over. It passed from east to west; and as his window faced the south, they only glanced against it obliquely[a]. He afterwards witnessed, in August, a similar emigration of myriads of a kind of beetle (*Carabus vulgaris*, L.)[b].—Another writer in the same work, H. Kapp, observed on a calm sunny day a prodigious flight of the noxious cabbage-butterfly (*Papilio Brassicæ*, L.), which passed from north-east to south-west, and lasted two hours[c]. Kalm saw these last insects midway in the British Channel[d]. Lindley, a writer in the *Royal Military Chronicle*, tells us, that in Brazil, in the beginning of March 1803, for many days successively there was an immense flight of white and yellow butterflies, probably of the same tribe as the cabbage butterfly. They were observed never to settle, but proceeded in a direction from north-west to south-east. No buildings seemed to stop them from steadily pursuing their course; which being to the ocean, at only a small distance, they must consequently perish. It is remarked that at this time no other kind of butterfly is to be seen,

[a] *Naturforsch.* vi. 111.
[b] Ibid. xi. 95.
[c] Ibid. 94.
[d] *Travels*, i. 13.

though the country usually abounds in such a variety[a].—Major Moor, while stationed at Bombay, as he was playing at chess one evening with a friend in Old Woman's Island, near that place, witnessed an immense flight of bugs (*Cimices*), which were going westward. They were so numerous as to cover every thing in the apartment in which he was sitting.—When staying at Aldeburgh, on the eastern coast, I have, at certain times, seen innumerable insects upon the beach close to the waves, and apparently washed up by them. Though wetted, they were quite alive. It is remarkable, that of the emigrating insects here enumerated, the majority—for instance the Libellulæ, Coccinellæ, Carabi, Cicadæ, &c.—are not usually social insects, but seem to congregate, like swallows, merely for the purpose of emigration. What incites them to this is one of those mysteries of nature, which at present we cannot penetrate. A scarcity of food urges the locusts to shift their quarters; and too confined a space to accommodate their numbers occasions the bees to swarm: but neither of these motives can operate in causing unsocial insects to congregate. It is still more difficult to account for the impulse that urges these creatures, with their filmy wings and fragile form, to attempt to cross the ocean, and expose themselves, one would think, to inevitable destruction. Yet, though we are unable to assign the cause of this singular instinct, some of the reasons which induced the Creator to endow them with it may be conjectured. This is clearly one of the modes by which their numbers are kept within due limits, as, doubtless, the great majority of these adventurers perish in the waters. Thus, also, a

[a] *R. Milit. Chron.* for March 1815, p. 452.

great supply of food is furnished to those fish in the sea itself, which at other seasons ascend the rivers in search of them; and this probably is one of the means, if not the only one, to which the numerous islands of this globe are indebted for their insect population. Whether the insects I observed upon the beach wetted by the waves, had flown from our own shores, and falling into the water had been brought back by the tide; or whether they had succeeded in the attempt to pass from the continent to us, by flying as far as they could, and then falling had been brought by the waves, cannot certainly be ascertained; but Kalm's observation inclines me to the latter opinion.

The next order of imperfect associations is that of those insects which feed together:—these are of two descriptions—those that associate in their *first* or *last* state only, and those that associate in *all* their states. The first of these associations is often very short-lived: a patch of eggs is glued to a leaf; when hatched, the little larvæ feed side by side very amicably, and a pleasant sight it is to see the regularity with which this work is often done, as if by word of command; but when the leaf that served for their cradle is consumed, their society is dissolved, and each goes where he can to seek his own fortune, regardless of the fate or lot of his brethren. Of this kind are the larvæ of the saw-fly of the gooseberry, whose ravages I have recorded before[a], and that of the cabbage-butterfly; the latter, however, keep longer together, and seldom wholly separate. In their final state, I have noticed that the individuals of *Thrips Physapus*, the fly that causes us in hot weather such intolerable titillation, are very fond of each other's company when they feed. To-

[a] Vol. I. 4th Ed. 195.

wards the latter end of last July, walking through a wheat-field, I observed that all the blossoms of *Convolvulus arvensis*, though very numerous, were interiorly turned quite black by the infinite number of these insects, which were coursing about within them.

But the most interesting insects of this order are those which associate in *all* their states.—Two populous tribes, the great devastators of the vegetable world, the one in warm and the other in cold climates, to which I have already alluded under the head of emigrations—you perceive I am speaking of *Aphides* and *Locusts*—are the best examples of this order: although, concerning the societies of the first, at present we can only say that they are merely the result of a common origin and station: but those of the latter, the locusts, wear more the appearance of design, and of being produced by the social principle.

So much as the world has suffered from these animals [a], it is extraordinary that so few observations have been made upon their history, economy, and mode of proceeding. One of the best accounts seems to be that of Professor Pallas, in his *Travels into the Southern Provinces of the Russian Empire*. The species to which his principal attention was paid appears to have been the *Gryllus italicus*, in its larva and pupa states. "In serene warm weather," says he, "the locusts are in full motion in the morning immediately after the evaporation of the dew; and if no dew has fallen, they appear as soon as the sun imparts his genial warmth. At first some are seen running about like messengers among the reposing swarms, which are lying partly compressed upon the ground, at the side of small eminences, and partly attached to tall

[a] See Vol. I. 4th Ed. 212.

plants and shrubs. Shortly after the whole body begins to move forward in one direction and with little deviation. They resemble a swarm of ants, all taking the same course, at small distances, but without touching each other: they uniformly travel towards a certain region as fast as a fly can run, and without leaping, unless pursued; in which case, indeed, they disperse, but soon collect again and follow their former route. In this manner they advance from morning to evening without halting, frequently at the rate of a hundred fathoms and upwards in the course of a day. Although they prefer marching along high roads, footpaths, or open tracts; yet when their progress is opposed by bushes, hedges, and ditches, they penetrate through them: their way can only be impeded by the waters of brooks or canals, as they are apparently terrified at every kind of moisture. Often, however, they endeavour to gain the opposite bank with the aid of overhanging boughs; and if the stalks of plants or shrubs be laid across the water, they pass in close columns over these temporary bridges; on which they even seem to rest and enjoy the refreshing coolness. Towards sunset the whole swarm gradually collect in parties, and creep up the plants, or encamp on slight eminences. On cold, cloudy, or rainy days they do not travel.—As soon as they acquire wings they progressively disperse, but still fly about in large swarms[a]."

"In the month of May, when the ovaries of these insects were ripe and turgid," says Dr. Shaw[b], "each of these swarms began gradually to disappear, and retired into the Mettijiah, and other adjacent plains, where

[a] Pallas, ii. 422-6. [b] *Travels*, 187.

they deposited their eggs. These were no sooner hatched in June, than each of the broods collected itself into a compact body, of a furlong or more in square; and marching afterwards directly forwards toward the sea, they let nothing escape them——*they kept their ranks, like men of war;* climbing over, as they advanced, every tree or wall that was in their way; nay, they entered into our very houses and bed-chambers, like *so many thieves.*——A day or two after one of these hordes was in motion, others were already hatched to march and glean after them.——Having lived near a month in this manner——they arrived at their full growth, and threw off their *nympha-state* by casting their outward skin. To prepare themselves for this change, they clung by their hinder feet to some bush, twig, or corner of a stone; and immediately, by using an undulating motion, their heads would first break out, and then the rest of their bodies. The whole transformation was performed in seven or eight minutes; after which they lay for a small time in a torpid and seemingly in a languishing condition; but as soon as the sun and the air had hardened their wings, by drying up the moisture that remained upon them after casting their sloughs, they reassumed their former voracity, with an addition of strength and agility. Yet they continued not long in this state before they were entirely dispersed." The species Dr. Shaw here speaks of is probably not the *Gryllus migratorius*, L.

The old Arabian fable, that they are directed in their flights by a leader or king [a], has been adopted: but I

[a] Bochart, *Hierozoic.* ii. l. 4. c. 2. 460.

think without sufficient reason, by several travellers. Thus Benjamin Bullivant, in his observations on the Natural History of New England[a], says that "the locusts have a kind of regimental discipline, and as it were some commanders, which show greater and more splendid wings than the common ones, and arise first when pursued by the fowls or the feet of the traveller, as I have often seriously remarked." And in like terms Jackson observes, that "they have a government amongst themselves similar to that of the bees and ants; and when the (*Sultan Jerraad*) king of the locusts rises, the whole body follow him, not one solitary straggler being left behind[b]." But that locusts have leaders, like the bees or ants, distinguished from the rest by the size and splendour of their wings, is a circumstance that has not yet been established by any satisfactory evidence; indeed, very strong reasons may be urged against it. The nations of bees and ants, it must be observed, are housed together in one nest or hive, the whole population of which is originally derived from one common mother, and the leaders of the swarms in each are the females. But the armies of locusts, though they herd together, travel together, and feed together, consist of an infinity of separate families, all derived from different mothers, who have laid their eggs in separate cells or houses in the earth; so that there is little or no analogy between the societies of locusts and those of bees and ants; and this pretended sultan is something quite different from the queen-bee or the female ants. It follows, therefore, that as the locusts have no common mother, like the bees, to lead their swarms, there

[a] In *Philos. Trans.* for 1698. [b] Jackson's *Marocco*, 51.

is no one that nature, by a different organization and ampler dimensions, and a more august form, has destined to this high office. The only question remaining is, whether one be elected from the rest by common consent as their leader, or whether their instinct impels them to follow the first that takes flight or alights. This last is the learned Bochart's opinion, and seems much the most reasonable[a]. The absurdity of the other supposition, that an election is made, will appear from such queries as these, at which you may smile—Who are the electors? Are the myriads of millions all consulted, or is the elective franchise confined to a few? Who holds the courts and takes the votes? Who casts them up and declares the result? When is the election made?—The larvæ appear to be as much under government as the perfect insect.—Is the monarch then chosen by his peers when they first leave the egg and emerge from their subterranean caverns? or have larva, pupa, and imago each their separate king? The account given us in Scripture is certainly much the most probable, that the locusts have no king, though they observe as much order and regularity in their movements as if they were under military discipline, and had a ruler over them[b]. Some species of ants, as we learn from the admirable history of them by M. P. Huber, though they go forth by common consent upon their military expeditions, yet the order of their columns keeps perpetually changing; so that those who lead the van at the first setting out, soon fall into the rear, and others take their place: their successors do the same; and such is the constant order of their march.

[a] Bochart, *Hierozoic.* ubi supra. [b] Proverbs xxx. 27.

It seems probable, as these columns are extended to a considerable length, that the object of this successive change of leaders is to convey constant intelligence to those in the rear, of what is going forward in the van. Whether any thing like this takes place for the regulation of their motions in the innumerable locust-armies, which are sometimes co-extensive with vast kingdoms; or whether their instinct simply directs them to follow the first that moves or flies, and to keep their measured distance, so that, as the prophet speaks, "one does not thrust another, and they walk every one in his path[a]," must be left to future naturalists to ascertain. And I think that you will join with me in the wish that travellers, who have a taste for Natural History, and some knowledge of insects, would devote a share of attention to the proceedings of these celebrated animals, so that we might have facts instead of fables.

The last order of imperfect associations approaches nearer to perfect societies, and is that of those insects which the social principle urges to unite in some common work for the benefit of the community.

Amongst the *Coleoptera*, *Ateuchus pilularius*, F., a beetle before mentioned, acts under the influence of this principle. "I have attentively admired their industry and mutual assisting of each other," says Catesby, "in rolling those globular balls from the place where they made them, to that of their interment, which is usually the distance of some yards, more or less. This they perform breech foremost, by raising their hind parts, forcing along the ball with their hind feet. Two or three of

[a] Joel ii. 8.

them are sometimes engaged in trundling one ball, which, from meeting with impediments from the unevenness of the ground, is sometimes deserted by them: it is however attempted by others with success, unless it happens to roll into some deep hollow chink, where they are constrained to leave it; but they continue their work by rolling off the next ball that comes in their way. None of them seem to know their own balls, but an equal care for the whole appears to affect all the community [a]."

Many larvæ also of *Lepidoptera* associate with this view, some of which are social only during part of their existence, and others during the whole of it. The first of these continue together while their united labours are beneficial to them; but when they reach a certain period of their life, they disperse and become solitary. Of this kind are the caterpillars of a little butterfly (*Papilio Cinxia*) which devour the narrow-leaved plantain. The families of these, usually amounting to about a hundred, unite to form a pyramidal silken tent, containing several apartments, which is pitched over some of the plants that constitute their food, and shelters them both from the sun and the rain. When they have consumed the provision which it covers, they construct a new one over other roots of this plant; and sometimes four or five of these encampments may be seen within a foot or two of each other. Against winter they weave and erect a stronger habitation of a rounder form, not divided by any partitions, in which they lie heaped one upon another, each being rolled up. About April they separate, and continue solitary till they assume the pupa.

[a] Catesby's *Carolina*, ii. 111. See above, Vol. I. 4th Ed. 349.

Reaumur, to whom I am indebted for this account, has also given us an interesting history of another insect, the gold-tail-moth before mentioned, whose caterpillars are of this description. They belong to that family of Bombyces, which envelop their eggs in hair plucked from their own body. As soon as one of these young caterpillars is disclosed from the egg, it begins to feed; another quickly joins it, placing itself by its side; thus they proceed in succession till a file is formed across the leaf:—a second is then begun; and after this is completed, a third—and so they proceed till the whole upper surface of the leaf is covered:—but as a single leaf will not contain the whole family, the remainder take their station upon the adjoining ones. No sooner have they satisfied the cravings of hunger, than they begin to think of erecting a common habitation, which at first is only a vaulted web, that covers the leaf they inhabit, but by their united labours in due time grows into a magnificent tent of silk, containing various apartments sufficient to defend and shelter them all from the attack of enemies and the inclemency of the seasons. As our caterpillars, like eastern monarchs, are too delicate to adventure their feet upon the rough bark of the tree upon which they feed, they lay a silken carpet over every road and pathway leading to their palace, which extends as far as they have occasion to go for food. To the habitation just described they retreat during heavy rains, and when the sun is too hot:—they likewise pass part of the night in them;—and, indeed, at all times some may usually be found at home. Upon any sudden alarm they retreat to them for safety, and also when they cast their skins:—in the winter they are wholly confined

to them, emerging again in the spring: but in May and June they entirely desert them; and, losing all their love for society, live in solitude till they become pupæ, which takes place in about a month. When they desert their nests, the spiders take possession of them; which has given rise to a prevalent though most absurd opinion, that they are the parents of these caterpillars[a].

With other caterpillars the association continues during the whole of the larva state. De Geer mentions one of the *Tenthredinidæ* of this description which form a common nidus by connecting leaves together with silken threads, each larva moreover spinning a tube o the same material for its own private apartment, in which it glides backwards and forwards upon its back[b]. I have observed similar nidi in this country; the insects that form them belong to the Fabrician genus *Lyda*.

The most remarkable insects, however, that arrange under this class of imperfect associates, are those that observe a particular order of march. Though they move without beat of drum, they maintain as much regularity in their step as a file of soldiers. It is a most agreeable sight, says one of Nature's most favoured admirers, Bonnet, to see several hundreds of the larvæ of *P. B. Neustria* marching after each other, some in straight lines, others in curves of various inflection, resembling, from their fiery colour, a moving cord of gold stretched upon a silken ribband of the purest white; this ribband is the carpeted causeway that leads to their leafy pasture from their nest. Equally amusing is the progress of another moth, the *Pityocampa*, before no-

Vol. I. 4th Ed. 477. Reaumur, ii. 125. [b] De Geer, ii. 1029.

ticed; they march together from their common citadel, consisting of pine-leaves united and inwoven with the silk which they spin, in a single line: in following each other they describe a multitude of graceful curves of varying figure, thus forming a series of living wreaths, which change their shape every moment:—all move with a uniform pace, no one pressing too forward or loitering behind; when the first stops, all stop, each defiling in exact military order[a].

A still more singular and pleasing spectacle, when their regiments march out to forage, is exhibited by the *Processionary Bombyx*. This moth, which is a native of France, and has not yet been found in this country, inhabits the oak. Each family consists of from 600 to 800 individuals. When young, they have no fixed habitation, but encamp sometimes in one place and sometimes in another, under the shelter of their web: but when they have attained two-thirds of their growth, they weave for themselves a common tent, before described[b]. About sun-set the regiment leaves its quarters; or, to make the metaphor harmonize with the trivial name of the animal, the monks their cœnobium. At their head is a chief, by whose movements their procession is regulated. When he stops, all stop, and proceed when he proceeds; three or four of his immediate followers succeed in the same line, the head of the second touching the tail of the first; then comes an equal series of pairs, next of threes, and so on as far as fifteen or twenty. The whole procession moves regularly on

[a] Bonnet, ii. 57. [b] Vol. I. 4th Ed. 478.

with an even pace, each file treading upon the steps of those that precede it. If the leader, arriving at a particular point, pursues a different direction, all march to that point before they turn. Probably in this they are guided by some scent imparted to the tracks by those that pass over them. Sometimes the order of procession is different; the leader, who moves singly, is followed by two, these are succeeded by three, then come four, and so on. When the leader,—who in nothing differs from the rest, and is probably the caterpillar nearest the entrance to the nest, followed, as I have described,—has proceeded to the distance of about two feet, more or less, he makes a halt; during which those which remain come forth, take their places, the company forms into files, the march is resumed, and all follow as regularly as if they kept time to music. These larvæ may be occasionally found at mid-day out of their nests, packed close one to another without making any movement; so that, although they occupy a space sufficiently ample, it is not easy to discover them. At other times, instead of being simply laid side by side, they are formed into singular masses, in which they are heaped one upon another, and as it were interwoven together. Thus also they are disposed in their nests. Sometimes their families divide into two bands, which never afterwards unite [a].

I have nothing further of importance to communicate to you on imperfect societies: in my next I shall begin the most interesting subject that Entomology offers; a subject, to say the least, including as great a portion both of instruction and amusement as any branch of Na-

[a] Reaumur, ii. 180.

tural History affords;—I mean those *perfect* associations which have for their great object the multiplication of the species, and the education, if such a term may be here employed, of the young. This is too fertile a theme to be confined to a single letter, but must occupy several.

I am, &c.

LETTER XVII.

SOCIETIES OF INSECTS CONTINUED.

PERFECT SOCIETIES. (*White Ants and Ants.*)

THE associations of insects of which my last letter gave you a detail, were of a very imperfect kind, both as to their object and duration: but those which I am now to lay before you exhibit the semblance of a nearer approach, both in their principle and its results, to the societies of man himself. There are two kindred sentiments, that in these last act with most powerful energy —desire and affection.—From the first proceed many wants that cannot be satisfied without the intercourse, aid, and co-operation of others; and by the last we are impelled to seek the good of certain objects, and to delight in their society. Thus self-love combines with philanthropy to produce the social principle, both desire and love alternately urging us to an intercourse with each other; and from these in union originate the multiplication and preservation of the species. These two passions are the master-movers in this business; but there is a third subsidiary to them, which, though it trenches upon the social principle, considered abstractedly, is often a powerful bond of union in separate so-

cieties—you will readily perceive that I am speaking of fear;—under the influence of this passion these are drawn closer together, and unite more intimately for defence against some common enemy, and to raise works of munition that may resist his attack.

The main instrument of association is language, and no association can be perfect where there is not a common tongue. The origin of nationality was difference of speech:—at Babel, when tongues were divided, nations separated. Language may be understood in a larger sense than to signify inflections of the voice,—it may well include all the means of making yourself understood by another, whether by gestures, sounds, signs, or words: the two first of these kinds may be called natural language, and the two last arbitrary or artificial.

I have said that perfect societies of insects exhibit the *semblance* of a nearer approach, both in their principle and its results, to the societies of man himself, because, unless we could perfectly understand what instinct is, and how it acts, we cannot, without exposing ourselves to the charge of temerity, assert that these are precisely the same.

But when we consider the object of these societies, the preservation and multiplication of the species; and the means by which that object is attained, the united labours and co-operation of perhaps millions of individuals, it seems as if they were impelled by passions very similar to those main-springs of human associations, which I have just enumerated. Desire appears to stimulate them—love to allure them—fear to alarm them. They want a habitation to reside in, and food for their subsistence. Does not this look as if desire were the

operating cause, which induces them to unite their labours to construct the one and provide the other? Their nests contain a numerous family of helpless brood. Does not love here seem to urge them to that exemplary and fond attention, and those unremitted and indefatigable exertions manifested by the whole community for the benefit of these dear objects? Is it not also evidenced by their general and singular attachment to their females, by their mutual caresses, by their feeding each other, by their apparent sympathy with suffering individuals and endeavours to relieve them, by their readiness to help those that are in difficulty, and finally by their sports and assemblies for relaxation? That fear produces its influence upon them seems no less evident, when we see them, agitated by the approach of enemies, endeavour to remove what is most dear to them beyond their reach, unite their efforts to repel their attacks, and to construct works of defence. They appear to have besides a common language; for they possess the faculty, by significative gestures and sounds, of communicating their wants and ideas to each other.

There are, however, the following great differences between human societies and those of insects. Man is susceptible of individual attachment, which forms the basis of his happiness, and the source of his purest and dearest enjoyments:—whereas the love of insects seems to be a kind of patriotism that is extended to the whole community, never distinguishing individuals, unless, as in the instance of the female bee, connected with that great object.

Man also, endowed with reason, forms a judgement from circumstances, and by a variety of means can at-

tain the same end. Besides the language of nature, gestures, and exclamations, which the passions produce, he is gifted with the divine faculty of speech, and can express his thoughts by articulate sounds or artificial language.—Not so our social insects. Every species has its peculiar mode of proceeding, to which it adheres as to the law of its nature, never deviating but under the control of imperious circumstances; for in particular instances, as you will see when I come to treat of their instincts, they know how to vary, though not very materially, from the usual mode[a]. But they never depart, like man, from the general system; and, in common with the rest of the animal kingdom, they have no articulate language.

Human associations, under the direction of reason and revelation, are also formed with higher views,—I mean as to government, morals, and religion:—with respect to the last of these, the social insects of course can have nothing to do, except that by their wonderful proceedings they give man an occasion of glorifying his great Creator; but in their instincts, extraordinary as it may seem, they exhibit a semblance of the two former, as will abundantly appear in the course of our correspondence.

I shall not detain you longer by prefatory remarks from the amusing scene to which I am eager to introduce you; but the following observations of M. P. Huber

[a] Plusieurs d'entre eux (*Insectes*) savent user de ressources ingénieuses dans les circonstances difficiles : ils sortent alors de leur routine accoutumée et semblent agir d'après la position dans laquelle ils se trouvent; c'est là sans doute l'un des phénomènes les plus curieux de l'histoire naturelle. Huber, *Nouvelles Observations sur les Abeilles*, ii. 198.—Compare also ibid. 250, note N. B.

on this subject are so just and striking, that I cannot refrain from copying them.

"The history of insects that live in solitude consists of their generation, their peculiar habits, the metamorphoses they undergo; their manner of life under each successive form; the stratagems for the attack of their enemies, and the skill with which they construct their habitation: but that of insects which form numerous societies, is not confined to some remarkable proceedings, to some peculiar talent: it offers new relations, which arise from common interest; from the equality or superiority of rank; from the part which each member supports in the society;—and all these relations suppose a connexion between the different individuals of which it consists, that can scarcely exist but by the intervention of language: for such may be called every mode of expressing their wishes, their wants, and even their ideas, if that name may be given to the impulses of instinct. It would be difficult to explain in any other way that concurrence of all wills to one end, and that species of harmony which the whole of their institution exhibits."

The great end of the societies of insects being the rapid multiplication of the species, Providence has employed extraordinary means to secure the fulfilment of this object, by creating a particular order of individuals in each society, which, freed from sexual pursuits, may give themselves wholly to labour, and thus absolve the females from every employment but that of furnishing the society from time to time with a sufficient supply of eggs to keep up the population to its proper standard. In the case of the Termites, the office of working for the society, as these insects belong to an order whose

metamorphosis is *semi-complete*, devolves upon the larvæ; the neuters, unless these should prove to be the larvæ of males, being the soldiers of the community.

From this circumstance perfect societies may be divided into two classes; the first including those whose workers are *larvæ*, and the second those whose workers are *neuters*[a]. The white ants belong to the former of these classes, and the social *Hymenoptera* to the latter.

Before I begin with the history of the societies of white ants, I must notice a remark that has been made applying to societies in general—that numbers are essential to the full development of the instinct of social animals. This has been observed by Bonnet with respect to the beaver[b]; by Reaumur of the hive-bee; and by M. P. Huber of the humble-bee[c]. Amongst hymenopterous social insects, however, the observation seems not universally applicable, but only under particular circumstances; for in incipient societies of ants, humble-bees, and wasps, one female lays the foundations of them at first by herself; and the first brood of neuters that is hatched is very small.

I have on a former occasion given you some account of the devastation produced by the white ants, or *Termites*, the species of which constitute the first class of

[a] I employ occasionally the term *neuters*, though it is not perfectly proper, for the sake of convenience;—strictly speaking, they may rather be regarded as imperfect or sterile females. Yet certainly, as the imperfection of their organization unfits them for sexual purposes, the term *neuter* is not absolutely improper.

[b] *Œuv.* ix. 163.

[c] M. P. Huber in *Linn. Trans.* vi. 256. Reaum. v.

perfect societies[a]; I shall now relate to you some further particulars of their history, which will, I hope, give you a better opinion of them.

The majority of these animals are natives of tropical countries, though two species are indigenous to Europe; one of which, thought to have been imported, is come so near to us as Bourdeaux. The fullest account hitherto given of their history is that of Mr. Smeathman, in the *Philosophical Transactions* for 1781; which, since it has in many particulars been confirmed by the observations of succeeding naturalists, though in some things he was evidently mistaken, I shall abridge for you, correcting him where he appears to be in error, and adding from Latreille, and the MS. of a French naturalist resident on the spot, kindly furnished by W. J. Hooker, esq.[b], what they have observed with respect to those of Bourdeaux and Ceylon. The white ants, though they belong to the *Neuroptera* order, borrow their instinct from the hymenopterous social tribes, and in conjunction with the ants (*Formica*) connect the two orders. Their societies consist of five different descriptions of individuals—workers or larvæ—nymphs or pupæ—neuters or soldiers—males and females.

1. The *workers* or larvæ, answering to the hymenopterous neuters, are the most numerous and at the same time most active part of the community; upon whom devolves the office of erecting and repairing the buildings, collecting provisions, attending upon the female,

[a] Vol. I. 4th Ed. 241.

[b] Author of a very interesting *Tour in Iceland*, a splendid Monograph on the Genus *Jungermannia*, &c.

conveying the eggs when laid to what Smeathman calls the nurseries, and feeding the young larvæ till they are old enough to take care of themselves. They are distinguished from the soldiers by their diminutive size, by their round heads and shorter mandibles.

2. The *nymphs* or pupæ. These were not noticed by Smeathman, who mistook the neuters for them:—they differ in nothing from the larvæ, and probably are equally active, except that they have rudiments of wings, or rather the wings folded up in cases (*Pterothecæ*). They were first observed by Latreille; nor did they escape the author of the MS. above alluded to, who mistook them for a different kind of larvæ.

3. The *neuters*, erroneously called by Smeathman pupæ. These are much less numerous than the workers, bearing the proportion of one to one hundred, and exceeding them greatly in bulk. They are also distinguishable by their long and large head, armed with very long subulate mandibles. Their office is that of sentinels; and when the nest is attacked, to them is committed the task of defending it. These neuters are quite unlike those in the *Hymenoptera* perfect societies, which seem to be a kind of abortive females, and there is nothing analogous to them in any other department of Entomology.

4. and 5. *Males* and *females*, or the insects arrived at their state of perfection, and capable of continuing the species. There is only one of each in every separate society; they are exempted from all participation in the labours and employments occupying the rest of the community, that they may be wholly devoted to the furnishing of constant accessions to the population of the colony. Though at their first disclosure from the pupa

they have four wings, like the female ants they soon cast them; but they may then be distinguished from the blind larvæ, pupæ, and neuters, by their large and prominent eyes[a].

The first establishment of a colony of Termites takes place in the following manner. In the evening, soon after the first tornado, which at the latter end of the dry season proclaims the approach of the ensuing rains, these animals, having attained to their perfect state, in which they are furnished and adorned with two pair of wings, emerge from their clay-built citadels by myriads and myriads, to seek their fortune. Borne on these ample wings, and carried by the wind, they fill the air, entering the houses, extinguishing the lights, and even sometimes being driven on board the ships that are not far from the shore. The next morning they are discovered covering the surface of the earth and waters: deprived of the wings which before enabled them to avoid their numerous enemies, and which are only calculated to carry them a few hours, and looking like large maggots; from the most active, industrious, and rapacious, they are now become the most helpless and cowardly beings in nature, and the prey of innumerable enemies, to the smallest of which they make not the least resistance. Insects, especially ants, which are always on the hunt for them, leaving no place unexplored; birds, reptiles, beasts, and even man himself, look upon this event as their harvest, and, as you have been told before, make

[a] The neuters in all respects bear a stronger analogy to the larvæ than to the perfect insects; and, after all, may possibly turn out to be larvæ, perhaps of the males. Huber seems to doubt their being neuters. *Nouv. Obs.* ii. 444, note *.

them their food; so that scarcely a single pair in many millions get into a place of safety, fulfill the first law of nature, and lay the foundation of a new community. At this time they are seen running upon the ground, the male after the female, and sometimes two chasing one, and contending with great eagerness, regardless of the innumerable dangers that surround them, who shall win the prize.

The workers, who are continually prowling about in their covered ways, occasionally meet with one of these pairs, and, being impelled by their instinct, pay them homage, and they are elected as it were to be king and queen, or rather father and mother, of a new colony[a]: all that are not so fortunate, inevitably perish; and, considering the infinite host of their enemies, probably in the course of the following day. The workers, as soon as this election takes place, begin to inclose their new rulers in a small chamber of clay, before described[b], suited to their size, the entrances to which are only large enough to admit themselves and the neuters, but much too small for the royal pair to pass through;—so that their state of royalty is a state of confinement, and so continues during the remainder of their existence. The impregnation of the female is supposed to take place after this confinement, and she soon begins to furnish the infant colony with new inhabitants. The care of feeding her and her male companion devolves upon the industrious larvæ,

[a] In this these animals vary from the usual instinct of the social *Hymenoptera*, the ants, the wasps, and the humble-bees—with whom the females lay the first foundations of the colonies, unassisted by any neuters;—but in the swarms of the hive-bee an election may perhaps in some instances be said to take place. [b] Vol. I. 4th Ed. 511.

who supply them both with every thing that they want. As she increases in dimensions, they keep enlarging the cell in which she is detained. When the business of oviposition commences, they take the eggs from the female, and deposit them in the nurseries[a]. Her abdomen now begins gradually to extend, till in process of time it is enlarged to 1500 or 2000 times the size of the rest of her body, and her bulk equals that of 20,000 or 30,000 workers. This part, often more than three inches in length, is now a vast matrix of eggs, which make long circumvolutions through numberless slender serpentine vessels:—it is also remarkable for its peristaltic motion, (in this resembling the female ant[b],) which, like the undulations of water, produces a perpetual and successive rise and fall over the whole surface of the abdomen, and occasions a constant extrusion of the eggs, amounting sometimes in old females to sixty in a minute, or eighty thousand and upwards in twenty-four hours[c]. As these females live two years in their perfect state, how astonishing must be the number produced in that time!

This incessant extrusion of eggs must call for the attention of a large number of the workers in the royal chamber (and indeed it is always full of them), to take them as they come forth and carry them to the nurseries; in which, when hatched, they are provided with food, and receive every necessary attention till they are able to shift for themselves.—One remarkable circumstance attends these nurseries—they are always covered with a

[a] See Vol. I. 4th Ed. 513. [b] Gould's *Account of English Ants*, 22.

[c] The late John Hunter dissected two young queens. In the abdomen he found two ovaries, consisting of many hundred oviducts, each containing innumerable eggs.

kind of mould, amongst which arise numerous globules about the size of a small pin's head. This is probably a species of *Mucor*; and by Mr. König, who found them also in nests of an East-Indian species of Termes, is conjectured to be the food of the larvæ.

The royal cell has besides some soldiers in it, a kind of body guard to the royal pair that inhabit it; and the surrounding apartments contain always many both labourers and soldiers in waiting, that they may successively attend upon and defend the common father and mother, on whose safety depend the happiness and even existence of the whole community; and whom these faithful subjects never abandon even in the last distress.

The manner in which the Termites feed the young brood, before they commence their active life and are admitted to share in the labours of the nest, has not, as far as I know, been recorded by any writer: I shall therefore leave them in their nurseries, and introduce you to the bustling scene which these creatures exhibit in their first state after they are become useful. To do this, in vain should I carry you to one of their nests—you would scarcely see a single one stirring—though, perhaps, under your feet there would be millions going and returning by a thousand different ways. Unless I possessed the power of Asmodeus in *Le Diable Boiteux*, of showing you their houses and covered ways with their roofs removed, you would return home as wise as you came; for these little busy creatures are taught by Providence always to work under cover. If they have to travel over a rock or up a tree, they vault with a coping of earth the route they mean to pursue, and they form subterranean paths and tunnels, some of a diameter

wider than the bore of a large cannon, on all sides from their habitation to their various objects of attack; or which sloping down (for they cannot well mount a surface quite perpendicular) penetrate to the depth of three or four feet under their nests into the earth, till they arrive at a soil proper to be used in the erection of their buildings. Were they, indeed, to expose themselves, the race would soon be annihilated by their innumerable enemies. This circumstance has deceived the author of the MS. account of those in Ceylon, who, speaking of the nests of these insects in that island, which he describes as twelve feet high, observes, that "they may be considered as a large city, which contains a great number of houses, and these houses an infinite number of cells or apartments:——these cells appear to me to communicate with each other, but not the houses. I have convinced myself, by bringing together the broken walls of one of the cavities of the nest or cone, that it does not communicate with any other, nor *with the exterior* of the cone—a very curious circumstance, which I will not undertake to explain. Other cavities communicate by a very narrow tunnel." By not looking for subterranean communications, he was probably led into this error.

You have before heard of their diligence in building. Does any accident happen to their various structures, or are they dislodged from any of their covered ways, they are still more active and expeditious in repairing. Getting out of sight as soon as possible,—and they run as fast or faster than any insect of their size,—in a single night they will restore a gallery of three or four yards in length. If, attacking the nest, you divide it in halves,

leaving the royal chamber, and thus lay open thousands of apartments, all will be shut up with their sheets of clay by the next morning;—nay, even if the whole be demolished, provided the king and the queen be left, every interstice between the ruins, at which either cold or wet can possibly enter, will be covered, and in a year the building will be raised nearly to its pristine size and grandeur.

Besides building and repairing, a great deal of their time is occupied in making necessary alterations in their mansion and its approaches. The royal presence-chamber, as the female increases in size, must be gradually enlarged, the nurseries must be removed to a greater distance, the chambers and exterior of the nest receive daily accessions to provide for a daily increasing population—and the direction of their covered ways must often be varied, when the old stock of provision is exhausted and new discovered.

The collection of provisions for the use of the colony is another employment, which necessarily calls for incessant attention: these to the naked eye appear like raspings of wood;—and they are, as you have seen, great destroyers of timber, whether wrought or unwrought:—but when examined by the microscope, they are found to consist chiefly of gums and the inspissated juices of plants, which, formed into little masses, are stored up in magazines made of clay.

When any one is bold enough to attack their nest and make a breach in its walls, the labourers, who are incapable of fighting, retire within, and give place to another description of its inhabitants, whose office it is to defend

the fortress when assailed by enemies:—these, as observed before, are the neuters or soldiers. If the breach be made in a slight part of the building, one of these comes out to reconnoitre; he then retires and gives the alarm. Two or three others next appear, scrambling as fast as they can one after the other;—to these succeed a large body, who rush forth with as much speed as the breach will permit, their numbers continually increasing during the attack. It is not easy to describe the rage and fury by which these diminutive heroes seem actuated. In their haste they frequently miss their hold, and tumble down the sides of their hill: they soon, however, recover themselves, and, being blind, bite every thing they run against. If the attack proceeds, the bustle and agitation increase to a ten-fold degree, and their fury is raised to its highest pitch. Wo to him whose hands or legs they can come at! for they will make their fanged jaws meet at the very first stroke, drawing as much blood as will counterpoise their whole body, and never quitting their hold, even though they are pulled limb from limb. The naked legs of the Negroes expose them frequently to this injury; and the stockings of the European are not sufficient to defend him.

On the other hand, if, after the first attack, you get a little out of the way, giving them no further interruption, supposing the assailant of their citadel is gone beyond their reach, in less than half an hour they will retire into the nest; and before they have all entered, you will see the labourers in motion, hastening in various directions towards the breach, every one carrying in his mouth a

mass of mortar half as big as his body[a], ready tempered: —this mortar is made of the finer parts of the gravel, which they probably select in the subterranean pits or passages before described, which, worked up to a proper consistence, hardens to the solid substance resembling stone, of which their nests are constructed. As fast as they come up, each sticks its burthen upon the breach; and this is done with so much regularity and dispatch, that although thousands, nay millions, are employed, they never appear to embarrass or interrupt one another. By the united labours of such an infinite host of creatures the wall soon rises and the breach is repaired.

While the labourers are thus employed, almost all the soldiers have retired quite out of sight, except here and there one, who saunters about amongst them, but never assists in the work. One in particular places himself close to the wall which they are building; and turning himself leisurely on all sides, as if to survey the proceedings, appears to act the part of an overseer of the works. Every now and then, at the interval of a minute or two, by lifting up his head and striking with his forceps upon the wall of the nest, he makes a particular noise, which is answered by a loud hiss from all the labourers, and appears to be a signal for dispatch; for, every time it is heard, they may be seen to redouble their pace, and apply to their work with increased diligence. Renew the attack, and this amusing scene will be repeated:—in rush the labourers,

[a] The anonymous author before alluded to, who observed the Ceylon white ants, says, that such was the size of the masses, which were tempered with a strong gluten, that they adhered though laid on the upper part of the breach.

all disappearing in a few seconds, and out march the military as numerous and vindictive as before.—When all is once more quiet, the busy labourers re-appear, and resume their work, and the soldiers vanish. Repeat the experiment a hundred times, and the same will always be the result;—you will never find, be the peril or emergency ever so great, that one order attempts to fight, or the other to work.

You have seen how solicitous the Termites are to move and work under cover and concealed from observation; this, however, is not always the case;—there is a species larger than *T. bellicosus*, whose proceedings I have been principally describing, which Mr. Smeathman calls the marching Termes (*Termes viarum*). He was once passing through a thick forest, when on a sudden a loud hiss, like that of serpents, struck him with alarm. The next step produced a repetition of the sound, which he then recognised to be that of white ants; yet he was surprised at seeing none of their hills or covered ways. Following the noise, to his great astonishment and delight he saw an army of these creatures emerging from a hole in the ground; their number was prodigious, and they marched with the utmost celerity. When they had proceeded about a yard they divided into two columns, chiefly composed of labourers, about fifteen abreast, following each other in close order, and going straight forward. Here and there was seen a soldier, carrying his vast head with apparent difficulty, and looking like an ox in a flock of sheep, who marched on in the same manner. At the distance of a foot or two from the columns many other soldiers were to be seen, standing still or pacing about as if upon the look-

out, lest some enemy should suddenly surprise their unwarlike comrades;—other soldiers, which was the most extraordinary and amusing part of the scene, having mounted some plants and placed themselves on the points of their leaves, elevated from ten to fifteen inches from the ground, hung over the army marching below, and by striking their forceps upon the leaf, produced at intervals the noise before mentioned. To this signal the whole army returned a hiss, and obeyed it by increasing their pace. The soldiers at these signal-stations sat quite still during the intervals of silence, except now and then making a slight turn of the head, and seemed as solicitous to keep their posts as regular sentinels. The two columns of this army united after continuing separate for twelve or fifteen paces, having in no part been above three yards asunder, and then descended into the earth by two or three holes. Mr. Smeathman continued watching them for above an hour, during which time their numbers appeared neither to increase nor diminish:—the soldiers, however, who quitted the line of march and acted as sentinels, became much more numerous before he quitted the spot. The larvæ and neuters of this species are furnished with eyes.

The societies of *Termes lucifugus*, discovered by Latreille at Bourdeaux, are very numerous; but instead of erecting artificial nests, they make their lodgement in the trunks of pines and oaks, where the branches diverge from the tree. They eat the wood the nearest the bark, or the alburnum, without attacking the interior, and bore a vast number of holes and irregular galleries. That part of the wood appears moist, and is covered with little gelatinous particles, not unlike

gum-arabic. These insects seem to be furnished with an acid of a very penetrating odour, which perhaps is useful to them for softening the wood[a]. The soldiers in these societies are as about one to twenty-five of the labourers[b]. The anonymous author of the observations on the Termites of Ceylon seems to have discovered a sentry-box in his nests. "I found," says he, "in a very small cell in the middle of the solid mass, (a cell about half an inch in height, and very narrow,) a larva with an enormous head.—Two of these individuals were in the same cell:—one of the two seemed placed as sentinel at the entrance of the cell. I amused myself by forcing the door two or three times;—the sentinel immediately appeared, and only retreated when the door was on the point to be stopped up, which was done in three minutes by the labourers."

I hope this account has reconciled you in some degree to the destructive Termites:—I shall next introduce you to social insects, concerning most of which you have probably conceived a more favourable opinion;—I mean those which constitute the second class of perfect societies, whose workers are not larvæ, but neuters. These all belong to the *Hymenoptera* order of Linné:—there are four kinds of insects in this order, (which you will find as fertile in the instructors of mankind, as you have seen it to be in our benefactors,) that, varying considerably from each other in their proceedings as social animals, separately merit your attention: namely, ants, wasps and hornets, humble-bees, and the hive-bee. I begin with the first.

[a] Latr. *Hist. Nat.* xiii. 64. [b] *Dict. Hist. Nat.* xxii. 57, 58.

Full of interesting traits as are the history and economy of the white-ants, and however earnestly they may induce you to wish you could be a spectator of them, yet they scarcely exceed those of an industrious tribe of insects, which are constantly passing under our eye. The *ant* has attracted universal notice, and been celebrated from the earliest ages, both by sacred and profane writers, as a pattern of prudence, foresight, wisdom, and diligence. Upon Solomon's testimony in their favour I have enlarged before; and for those of other ancient writers, I must refer you to the learned Bochart, who has collected them in his *Hierozoicon.*

In reading what the ancients say on this subject, we must be careful, however, to separate truth from error, or we shall attribute much more to ants than of right belongs to them. Who does not smile when he reads of ants that emulate the wolf in size, the dog in shape, the lion in its feet, and the leopard in its skin; ants, whose employment is to mine for gold, and from whose vengeance the furtive Indian is constrained to fly on the swift camel's back[a]? But when we find the writers of all nations and ages unite in affirming, that, having deprived it of the power of vegetating, ants store up grain in their nests, we feel disposed to give larger credit to an assertion, which, at first sight, seems to savour more of fact than of fable, and does not attribute more sagacity and foresight to these insects than in other instances they are found to possess. Writers in general, therefore, who have considered this subject, and some even of very late date, have taken it for granted that the ancients were correct in this notion.

[a] Bochart, *Hierozoic.* ii. l. iv. c. 22.

But when observers of nature began to examine the manners and economy of these creatures more narrowly, it was found, at least with respect to the European species of ants, that no such hoards of grain were made by them, and, in fact, that they had no magazines in their nests in which provisions of any kind were stored up. It was therefore surmised that the ancients, observing them carry about their pupæ, which in shape, size, and colour, not a little resemble a grain of corn, and the ends of which they sometimes pull open to let out the inclosed insect, mistook the one for the other, and this action for depriving the grain of the corculum. Mr. Gould, our countryman, was one of the first historians of the ant, who discovered that they did not store up corn; and since his time naturalists have generally subscribed to that opinion.

Till the manners of exotic ants are more accurately explored, it would, however, be rash to affirm that no ants have magazines of provisions; for although, during the cold of our winters in this country, they remain in a state of torpidity, and have no need of food, yet in warmer regions, during the rainy seasons, when they are probably confined to their nests, a store of provisions may be necessary for them. Even in northern climates, against wet seasons, they may provide in this way for their sustenance and that of the young brood, which, as Mr. Smeathman observes, are very voracious, and cannot bear to be long deprived of their food; else why do ants carry worms, living insects, and many other such things into their nests? Solomon's lesson to the sluggard has been generally adduced as a strong confirmation of the ancient opinion: it can, however, only relate to the species of a warm climate,

the habits of which, as I have just observed, are probably different from those of a cold one;—so that his words, as commonly interpreted, may be perfectly correct and consistent with nature, and yet be not at all applicable to the species that are indigenous to Europe. But I think, if Solomon's words are properly considered, it will be found that this interpretation has been fathered upon them, rather than fairly deduced from them. He does not affirm that the ant which he proposes to his sluggard as an example, laid up in her magazines stores of grain: "Go to the ant, thou sluggard, consider her ways and be wise; which, having neither captain, overseer, nor ruler, prepares her bread in the summer, and gathers her food in the harvest." These words may very well be interpreted simply to mean, that the ant, with commendable prudence and foresight, makes use of the proper seasons to collect a supply of provision sufficient for her purposes. There is not a word in them implying that she stores up grain or other provision. She prepares her bread, and gathers her food,—namely, such food as is suited to her,—in summer and harvest,—that is, when it is most plentiful,—and thus shows her wisdom and prudence by using the advantages offered to her. The words thus interpreted, which they may be without any violence, will apply to our European species as well as to those that are not indigenous.

I shall now bid farewell to the ancients, and proceed to lay before you what the observations of modern authors have enabled me to add to the history of ants:—the principal of these are Leeuwenhoeck, Swammerdam (who was the first that had recourse to artificial means for observing their proceedings), Linné, Bonnet, and

especially the illustrious Swedish entomologist De Geer. Gould also, who, though no systematical naturalist, was a man of sense and observation, has thrown great light upon the history of ants, and anticipated several of what are accounted the discoveries of more modern writers on this subject[a]. Latreille's *Natural History of Ants* is likewise extremely valuable, not only as giving a systematic

[a] M. P. Huber, in the account which, in imitation of De Geer, he has given of the discoveries made by his predecessors in the history of ants, having passed without notice, probably ignorant of the existence of such a writer, those of our intelligent countryman Gould, I shall here give a short analysis of them; from which it will appear, that he was one of their best, or rather their very best historian, till M. Huber's work came out. His *Account of English Ants* was published in 1747, long before either Linné or De Geer had written upon the subject.

I. *Species.* He describes five species of English ants; viz. 1. The hill ant (*Formica rufa*, L). 2. The jet ant (*F. fuliginosa*, Latr.). 3. The red ant (*Myrmica rubra*, Latr. *Formica*, Lin.): He observes, that this species alone is armed with a sting; whereas, the others make a wound with their mandibles, and inject the formic acid into it. 4. The common yellow ant (*F. flava*, Latr.): and 5. The small black ant (*F. fusca*, L.).

II. *Egg.* He observes that the eggs producing males and females are laid the earliest, and are the largest:—he seems, however, to have confounded the black and brown eggs of *Aphides* with those of ants.

III. *Larva.* These, when first hatched, he observes, are hairy, and continue in the larva state twelve months or more. He, as well as De Geer, was aware that the larvæ of *Myrmica rubra* do not, as other ants do, spin a cocoon when they assume the pupa.

IV. *Pupa.* He found that female ants continue in this state about six weeks, and males and neuters only a month.

V. *Imago.* He knew perfectly the sexes, and was aware that females cast their wings previous to their becoming mothers; that, at the time of their swarms, large numbers of both sexes become the prey of birds and fishes: that the surviving females, sometimes in numbers, go under ground, particularly in mole-hills, and lay eggs; but he had not discovered that they then act the part of neuters in

arrangement and descriptions of the species, but as concentrating the accounts of preceding authors, and adding several interesting facts *ex proprio penu*. The great historiographer of ants, however, is M. P. Huber; who has lately published a most admirable and interesting work upon them, in which he has far outstripped all his predecessors.—Such are the sources from which the following account of ants is principally drawn, intermixed with which you will find some occasional observations,—

the care of their progeny. He knew also, that when there was more than one queen in a nest, the rivals lived in perfect harmony.

With respect to the neuters, he had witnessed the homage they pay their queens or fertile females, continued even after their death; —this homage, he however observes, which is noticed by no other author, appears often to be temporary and local—ceasing at certain times, and being renewed upon a change of residence. He enlarges upon their exemplary care of the eggs, larvæ, and pupæ. He tells us that the eggs, as soon as laid, are taken by the neuters and deposited in heaps, and that the neuters brood them. He particularly notices their carrying them, with the larvæ and pupæ, daily from the interior to the surface of the nest and back again, according to the temperature; and that they feed the larvæ by disgorging the food from their own stomach. He speaks also of their opening the cocoons when the pupæ are ready to assume the imago, and disengaging them from them. With regard to their labours, he found that they work all night, except during violent rains:—that their instinct varies as to the station of their nest:—that their masonry is consolidated by no cement, but consists merely of mould;—that they form roads and trackways to and from their nests;—that they carry each other in sport, and sometimes lie heaped one on another in the sun.—He suspects that they occasionally emigrate;—he proves by a variety of experiments that they do not hoard up provisions. He found they were often infested by a particular kind of *Gordius*:—he had noticed also that the neuters of *F. rufa* and *flava* (which escaped M. Huber, though he observed it in *F. rufescens*, Latr.) are of two sizes, which the writer of this note can confirm by producing specimens:—and lastly, with Swammerdam, he had recourse to artificial colonies, the better to enable him to examine their proceedings, but not comparable to the ingenious apparatus of M. Huber.

which your partiality to your friend may, perhaps, induce you to think not wholly devoid of interest,—that it has been my fortune to make.

The societies of ants, as also of other *Hymenoptera*, differ from those of the Termites in having inactive larvæ and pupæ, the neuters or workers combining in themselves both the military and civil functions. Besides the helpless larvæ and pupæ, which have no locomotive powers, these societies consist of females, males, and workers. The office of the *females*, at their first exclusion distinguished by a pair of ample wings, (which however, as you have heard, they soon cast,) is the foundation of new colonies, and the furnishing of a constant supply of eggs for the maintenance of the population in the old nests as well as in the new. These are usually the least numerous part of the community[a]. The office of the *males*, which are also winged, and at the time of swarming are extremely numerous, is merely the impregnation of the females: after the season for this is passed, they die. Upon the *workers*[b] devolves, except in nascent colonies, all the work, as well as the defence of the community, of which they are the most numerous portion. In some societies of ants the workers are of two dimensions.—In the nests of *F. rufa* and *flava* such

[a] Gould says that the males and females are nearly equal in number, p. 62; but from Huber's observations it seems to follow that the former are most numerous, p. 96.

[b] That the neuter ants, like those of the hive-bee, are imperfectly organized females, appears from the following observation of M. Huber (*Nouv. Observ. &c.* ii. 443.)—" Les fourmis nous ont encore offert à cet égard une analogie très frappante ; à la vérité, nous n'avons jamais vu pondre les ouvrières, mais nous avons été témoins de leur accouplement. Ce fait pourroit être attesté par plusieurs membres

were observed by Gould, the size of one exceeding that of the other about one third [a]. (In my specimens, the large workers of *F. rufa* are nearly three times, and of *F. flava* twice, the size of the small ones.) All were equally engaged in the labours of the colony. Large workers were also noticed by M. P. Huber in the nests of *F. rufescens* [b], but he could not ascertain their office.

Having introduced you to the individuals of which the associations of ants consist, I shall now advert to the principal events of their history, relating first the fates of the *males* and *females*. In the warm days that occur from the end of July to the beginning of September, and sometimes later, the habitations of the various species of ants may be seen to swarm with winged insects, which are the males and females, preparing to quit for ever the scene of their nativity and education. Every thing is in motion—and the silver wings contrasted with the jet bodies which compose the animated mass, add a degree of splendour to the interesting scene. The bustle increases, till at length the males rise, as it were by a general impulse, into the air, and the females accompany them. The whole swarm alternately rises and falls with a slow movement to the height of about ten feet, the males flying obliquely with a rapid zigzag motion, and the females,

de la Société d'Histoire Naturelle de Génève, à qui nous l'avons fait voir; l'approche du mâle étoit toujours suivie de la mort de l'ouvrière; leur conformation ne permet donc pas qu'elles deviennent mères, mais l'instinct du mâle prouve du moins que ce sont des femelles."

[a] Gould, 103.

[b] M. Huber calls this an apterous female; yet he could not discover that they laid eggs; and he owns that they more nearly resembled the workers than the females; and that he should have considered them as such, had he seen them mix with them in their excursions. *Huber*, p. 251.

though they follow the general movement of the column, appearing suspended in the air, like balloons, seemingly with no individual motion, and having their heads turned towards the wind.

Sometimes the swarms of a whole district unite their infinite myriads, and, seen at a distance, produce an effect resembling the flashing of an aurora borealis. Rising with incredible velocity in distinct columns, they soar above the clouds. Each column looks like a kind of slender net-work, and has a tremulous undulating motion, which has been observed to be produced by the regular alternate rising and falling just alluded to. The noise emitted by myriads and myriads of these creatures does not exceed the hum of a single wasp. The slightest zephyr disperses them; and if in their progress they chance to be over your head, if you walk slowly on, they will accompany you, and regulate their motions by yours. The females continue sailing majestically in the centre of these numberless males, who are all candidates for their favour, each till some fortunate lover darts upon her, and, as the Roman youth did the Sabine virgins, drags his bride from the sportive crowd, and the nuptials are consummated in mid-air; though sometimes the union takes place on the summit of plants, but rarely in the nests[a]. After this *danse de l'amour* is celebrated, the males disappear, probably dying, or becoming, with many of the females, the prey of birds or fish[b]; for, since they do not return to the nest, they cannot be destroyed, as some have supposed, like the drone bees, by the neuters. That many, both males and females, become the

[a] De Geer, ii, 1104. [b] Gould, 99.

prey of fish, I am enabled to assert from my own observation.—In the beginning of August 1812, I was going up the Orford river in Suffolk, in a row-boat, in the evening, when my attention was caught by an infinite number of winged ants, both males and females, at which the fish were every where darting, floating alive upon the surface of the water. While passing the river, these had probably been precipitated into it, either by the wind, or by a heavy shower which had just fallen. And M. Huber after the same event observed the earth strewed with females that had lost their wings, all of which could not form colonies[a].

Captain Haverfield, R. N. gave me an account of an extraordinary appearance of ants observed by him in the Medway, in the autumn of 1814, when he was first-lieutenant of the Clorinde—which is confirmed by the following letter addressed by the surgeon of that ship, now Dr. Bromley, to Mr. MacLeay:

"In September 1814, being on the deck of the hulk to the Clorinde, my attention was drawn to the water by the first-lieutenant (Haverfield) observing there was something black floating down with the tide. On looking with a glass, I discovered they were insects.—The boat was sent, and brought a bucket full of them on board;—they proved to be a large species of ant, and extended from the upper part of Salt-pan reach out towards the Great Nore, a distance of five or six miles. The column appeared to be in breadth eight or ten feet, and in height about six inches, which I suppose must have been from their resting one upon another." Pur-

[a] Huber, 105.

chas seems to have witnessed a similar phenomenon on shore. "Other sorts (of ants)," says he, "there are many, of which some become winged and fill the air with swarms, which sometimes happens in England. On Bartholomew 1613 I was in the island of Foulness on our Essex shore, where were such clouds of these flying pismires, that we could no where fly from them, but they filled our clothes, yea the floors of some houses where they fell were in a manner covered with a black carpet of creeping ants; which they say drown themselves about that time of the year in the sea[a].

These ants were winged—whence, in the first instance here related, this immense column came was not ascertained. From the numbers here agglomerated, one would think that all the ant-hills of the counties of Kent and Surrey could scarcely have furnished a sufficient number of males and females to form it.

When Colonel Sir Augustus Frazer, of the Horse Artillery, was surveying on the 6th of October 1813 the scene of the battle of the Pyrenees from the summit of the mountain called Pena de Aya, or Les Quatre Couronnes, he and his friends were enveloped by a swarm of ants, so numerous as entirely to intercept their view, so that they were glad to remove to another station, in order to get rid of them.

The females that escape from the injury of the elements and their various enemies, become the founders of new colonies, doing all the work, as I have related in a former letter, that is usually done by the neuters[b]. M. P.

[a] *Pilgrimage*, 1090.

[b] M. Huber observes that fecundated females, after they have lost

Huber has found incipient colonies, in which were only a few workers engaged with their mother in the care of a small number of larvæ; and M. Perrot, his friend, once discovered a small nest, occupied by a solitary female, who was attending upon four pupæ only. Such is the foundation and first establishment of those populous nations of ants with which we every where meet.

But though the majority of females produced in a nest probably thus desert it, all are not allowed this liberty. The prudent workers are taught by their instinct that the existence of their community depends upon the presence of a sufficient number of females. Some therefore that are fecundated in or near the spot they forcibly detain, pulling off their wings, and keeping them prisoners till they are ready to lay their eggs, or are reconciled to their fate. De Geer in a nest of *F. rufa* observed that the workers compelled some females that were come out of the nest, to re-enter it[a]; and from M. P. Huber we learn that, being seized at the moment of fecundation, they are conducted into the interior of the formicary, when they become entirely dependent upon the neuters, who hanging pertinaciously to each leg prevent their going out, but at the same time attend upon them with the greatest care, feeding them regularly, and conducting them where the temperature is suitable to them, but never quitting them a single moment. By degrees these females become reconciled to their fate, and lose all desire of making their escape;—their abdomen enlarges, and they are no longer

their wings, make themselves a subterranean cell, some singly, others *in common*. From which it appears that some colonies have more than one female, from their first establishment.

[a] ii. 1071.

detained as prisoners, yet each is still attended by a body-guard—a single ant, which always accompanies her, and prevents her wants.—Its station is remarkable, it being mounted upon her abdomen, with its posterior legs upon the ground. These sentinels are constantly relieved: and to watch the moment when the female begins the important work of oviposition, and carry off the eggs, of which she lays four or five thousand or more in the course of the year, seems to be their principal office.

When the female is acknowledged as a mother, the workers begin to pay her a homage very similar to that which the bees render to their queen. All press round her, offer her food, conduct her by her mandibles through the difficult or steep passages of the formicary; nay, they sometimes even carry her about their city;—she is then suspended upon their jaws, the ends of which are crossed; and, being coiled up like the tongue of a butterfly, she is packed so close as to incommode the carrier but little. When she sets her down, others surround and caress her, one after another tapping her on the head with their antennæ. "In whatever apartment," says Gould, "a queen condescends to be present, she commands obedience and respect. An universal gladness spreads itself through the whole cell, which is expressed by particular acts of joy and exultation. They have a particular way of skipping, leaping, and standing upon their hind-legs, and prancing with the others. These frolics they make use of, both to congratulate each other when they meet, and to show their regard for the queen; some of them gently walk over her, others dance round her;—she is generally encircled with a cluster of attendants, who, if you separate them

from her, soon collect themselves into a body, and inclose her in the midst[a]." Nay, even if she dies, as if they were unwilling to believe it, they continue sometimes for months the same attentions to her, and treat her with the same courtly formality as if she were alive, and they will brush her and lick her incessantly[b].

This homage paid by the workers to their queens, according to Gould, is temporary and local;—when she has laid eggs in any cell, their attentions, he observed, seemed to relax, and she became unsettled and uneasy. In the summer months she is to be met with in various apartments in the colony; and eggs also are to be seen in several places, which induced him to believe that, having deposited a parcel in one, she retires to another for the same purpose, thus frequently changing her situation and attendants. As there are always a number of lodgements void of eggs but full of ants, she is never at a loss for an agreeable station and submissive retinue: and by the time she has gone her rounds in this manner, the eggs first laid are brought to perfection, and her old attendants are glad to receive her again. Yet this inattention after oviposition is not invariable; the female and neuters sometimes unite together in the same cell after the eggs are laid. On this occasion the workers divide their attention; and if you disturb them, some will run to the defence of their queen, as well as of the eggs, which last, however, are the great objects of their solicitude. This statement differs somewhat from M. Huber's; but different species vary in their instincts, which will account for this and similar dis-

[a] Gould, p. 24—
[b] Compare Gould p. 25, with Huber 125, note (1.)

sonances in authors who have observed their proceedings. Mr. Gould also noticed but very few females in ant-nests, sometimes only one; but M. Huber, who had better opportunities, found several, which he says live very peaceably together, showing none of that spirit of rivalry so remarkable in the queen bee.

And here I must close my narrative of the life and adventures of male and female ants; but, as it will be followed by a history of the still more interesting proceedings of the *workers*, I think you will not regret the exchange. I shall show these to you in many different views, under each of which you will find fresh reason to admire them. My only fear will be lest you should think the picture too highly coloured, and deem it incredible that creatures so minute should so far exceed the larger animals in wisdom, foresight, and sagacity, and make so near an approach in these respects to man himself.—My facts, however, are derived from authorities so respectable, that I think they will do away any bias of this kind that you may feel in your mind[a].

I need not here repeat what I have said in a former letter concerning the exemplary attention paid by these kind foster-mothers to the young brood of their colonies; nor shall I enlarge upon the building and nature of their habitations, which have been already noticed[b]:—but,

[a] It may be thought that many of the anecdotes related in the following history of the proceedings of neuter ants could not have been observed by any one, unless he had been admitted into an ant-hill; but it must be recollected that M. P. Huber, from whose work the most extraordinary facts are copied, invented a kind of ant-hive; so constructed as to enable him to observe their proceedings without disturbing them. [b] Vol. I. 4th Ed. 479.

without either of these, I have matter enough to fill the rest of this letter with interesting traits, while I endeavour to teach you their language, to develop their affections and passions, and to delineate their virtues;—while I show them to you when engaged in war, and enable you to accompany them both in their military expeditions and in their emigrations,—while I make you a witness of their indefatigable industry and incessant labours,— or invite you to be present, during their hours of relaxation, at their sports and amusements.

That ants, though they are mute animals, have the means of communicating to each other information of various occurrences, and use a kind of language which is mutually understood, will appear evident from the following facts.

If those at the surface of a nest are alarmed, it is wonderful in how short a time the alarm spreads through the whole nest. It runs from quarter to quarter; the greatest inquietude seems to possess the community; and they carry with all possible dispatch their treasures, the larvæ and pupæ, down to the lowest apartments. Amongst those species of ants that do not go much from home, sentinels seem to be stationed at the avenues of their city. Disturbing once the little heaps of earth thrown up at the entrances into the nest of *F. flava*, which is of this description, I was struck by observing a single ant immediately come out, as if to see what was the matter, and this three separate times.

The *F. herculanea*, L. inhabits the trunks of hollow trees on the continent, for it has not yet been found in England, upon which they are often passing to and fro.

M. Huber observed, that when he disturbed those that were at the greatest distance from the rest, they ran towards them, and, striking their head against them, communicated their cause of fear or anger,—that these, in their turn, conveyed in the same way the intelligence to others, till the whole colony was in a ferment, those neuters which were within the tree running out in crowds to join their companions in the defence of their habitation. The same signals that excited the courage of the neuters produced fear in the males and females, which, as soon as the news of the danger was thus communicated to them, retreated into the tree as to an asylum.

The legs of one of this gentleman's artificial formicaries were plunged into pans of water, to prevent the escape of the ants;—this proved a source of great enjoyment to these little beings, for they are a very thirsty race, and lap water like dogs[a]. One day, when he observed many of them tippling very merrily, he was so cruel as to disturb them, which sent most of the ants in a fright to the nest; but some more thirsty than the rest continued their potations. Upon this, one of those that had retreated returns to inform his thoughtless companions of their danger; one he pushes with his jaws; another he strikes first upon the belly, and then upon the breast; and so obliges three of them to leave off their carousing, and march homewards; but the fourth, more resolute to drink it out, is not to be discomfited, and pays not the least regard to the kind blows with which his compeer, solicitous for his safety, repeatedly belabours him:—at length, determined to have his way,

[a] Gould, 92. De Geer, ii. 1067. Huber, 5. 132.

he seizes him by one of his hind-legs, and gives him a violent pull:—upon this, leaving his liquor, the loiterer turns round, and opening his threatening jaws with every appearance of anger, goes very coolly to drinking again; but his monitor, without further ceremony, rushing before him, seizes him by his jaws, and at last drags him off in triumph to the formicary[a].

The language of ants, however, is not confined merely to giving intelligence of the approach or presence of danger; it is also co-extensive with all their other occasions for communicating their ideas to each other.

Some, whose extraordinary history I shall soon relate to you, engage in military expeditions, and often previously send out spies to collect information. These, as soon as they return from exploring the vicinity, enter the nest; upon which, as if they had communicated their intelligence, the army immediately assembles in the suburbs of their city, and begins its march towards that quarter whence the spies had arrived. Upon the march, communications are perpetually making between the van and the rear; and when arrived at the camp of the enemy, and the battle begins, if necessary, couriers are dispatched to the formicary for reinforcements[b].

If you scatter the ruins of an ant's nest in your apartment, you will be furnished with another proof of their language. The ants will take a thousand different paths, each going by itself, to increase the chance of discovery; they will meet and cross each other in all directions, and perhaps will wander long before they can find a spot

[a] Huber, 133. [b] Ibid. 237, 217, 167.

convenient for their reunion. No sooner does any one discover a little chink in the floor, through which it can pass below, than it returns to its companions, and, by means of certain motions of its antennæ, makes some of them comprehend what route they are to pursue to find it, sometimes even accompanying them to the spot; these, in their turn, become the guides of others, till all know which way to direct their steps[a].

It is well known also, that ants give each other information when they have discovered any store of provision. Bradley relates a striking instance of this. A nest of ants in a nobleman's garden discovered a closet, many yards within the house, in which conserves were kept, which they constantly attended till the nest was destroyed. Some in their rambles must have first discovered this depôt of sweets, and informed the rest of it. It is remarkable that they always went to it by the same track, scarcely varying an inch from it, though they had to pass through two apartments; nor could the sweeping and cleaning of the rooms discomfit them, or cause them to pursue a different route[b].

Here may be related a very amusing experiment of Gould's. Having deposited several colonies of ants (*F. fusca*) in flower-pots, he placed them in some earthen pans full of water, which prevented them from making excursions from their nest. When they had been accustomed some days to this imprisonment, he fastened small threads to the upper part of the pots, and extending them over the water pans fixed them in the

[a] Huber, 137. [b] Bradley, 134.

ground. The sagacious ants soon found out that by these bridges they could escape from their moated castle. The discovery was communicated to the whole society, and in a short time the threads were filled with trains of busy workers passing to and fro[a].

Ligon's account of the ants in Barbadoes affords another most convincing proof of this:—as he has told his tale in a very lively and interesting manner, I shall give it nearly in his own words.

"The next of these moving little animals are ants or pismires; and these are but of a small size, but great in industry; and that which gives them means to attain to this end is, they have all one soul. If I should say they are here or there, I should do them wrong, for they are every where; under ground, where any hollow or loose earth is; amongst the roots of trees; upon the bodies, branches, leaves and fruit of all trees; in all places without the houses and within; upon the sides, walls, windows, and roofs without; and on the floors, side walls, ceilings, and windows within; tables, cupboards, beds, stools, all are covered with them, so that they are a kind of ubiquitaries.——We sometimes kill a cockroach, and throw him on the ground; and mark what they will do with him: his body is bigger than a hundred of them, and yet they will find the means to take hold of him, and lift him up; and having him above ground, away they carry him, and some go by as ready assistants, if any be weary; and some are the officers that lead and show the way to the hole into which he must pass; and if the vancouriers perceive that the body of the cockroach lies across, and will not pass through the hole or arch

[a] Gould, 85.

through which they mean to carry him, order is given, and the body turned endwise, and this is done a foot before they come to the hole, and that without any stop or stay; and this is observable, that they never pull contrary ways.——A table being cleared with great care, by way of experiment, of all the ants that were upon it, and some sugar being put upon it, some, after a circuitous route, were observed to arrive at it, when again departing without tasting the treasure, they hastened away to inform their friends of their discovery, who upon this came by myriads;—"and when they are thickest upon the table," says he, "clap a large book (or any thing fit for that purpose) upon them, so hard as to kill all that are under it; and when you have done so, take away the book, and leave them to themselves but a quarter of an hour, and when you come again, you shall find all those bodies carried away. Other trials we make of their ingenuity, as this:—Take a pewter dish, and fill it half full of water, into which put a little gally-pot filled with sugar, and the ants will presently find it and come upon the table; but when they perceive it environed with water, they try about the brims of the dish where the gally-pot is nearest; and there the most venturous amongst them commits himself to the water, though he be conscious how ill a swimmer he is, and is drowned in the adventure: the next is not warned by his example, but ventures too, and is alike drowned; and many more, so that there is a small foundation of their bodies to venture; and then they come faster than ever, and so make a bridge of their own bodies[a]."

[a] *Hist of Barbadoes*, p. 63.

The fact being certain, that ants impart their ideas to each other, we are next led to inquire by what means this is accomplished. It does not appear that, like the bees, they emit any significative sounds; their language, therefore, must consist of signs or gestures, some of which I shall now detail. In communicating their fear or expressing their anger, they run from one to another in a semicircle, and strike with their head or jaws the trunk or abdomen of the ant to which they mean to give information of any subject of alarm. But those remarkable organs, their antennæ, are the principal instruments of their speech, if I may so call it, supplying the place both of voice and words. When the military ants before alluded to go upon their expeditions, and are out of the formicary, previously to setting off, they touch each other on the trunk with their antennæ and forehead;—this is the signal for marching; for, as soon as any one has received it, he is immediately in motion. When they have any discovery to communicate, they strike with them those that they meet in a particularly impressive manner.—If a hungry ant wants to be fed, it touches with its two antennæ, moving them very rapidly, those of the individual from which it expects its meal:—and not only ants understand this language, but even Aphides and Cocci, which are the milch kine of our little pismires, do the same, and will yield them their saccharine fluid at the touch of these imperative organs. The helpless larvæ also of the ants are informed by the same means when they may open their mouths to receive their food.

Next to their language, and scarcely different from it, are the modes by which they express their affections and aversions. Whether ants, with man and some of the

larger animals, experience any thing like attachment to individuals, is not easily ascertained; but that they feel the full force of the sentiment which we term patriotism, or the love of the community to which they belong, is evident from the whole series of their proceedings, which all tend to promote the general good. Distress or difficulty falling upon any member of their society, generally excites their sympathy, and they do their utmost to relieve it. M. Latreille once cut off the antennæ of an ant; and its companions, evidently pitying its sufferings, anointed the wounded part with a drop of transparent fluid from their mouth: and whoever attends to what is going forward in the neighbourhood of one of their nests, will be pleased to observe the readiness with which they seem disposed to assist each other in difficulties. When a burthen is too heavy for one, another will soon come to ease it of part of the weight, and if one is threatened with an attack, all hasten to the spot, to join in repelling it.

The satisfaction they express at meeting after absence is very striking, and gives some degree of individuality to their attachment. M. Huber witnessed the gesticulations of some ants, originally belonging to the same nest, that, having been entirely separated from each other four months, were afterwards brought together. Though this was equal to one-fourth of their existence as perfect insects, they immediately recognised each other, saluted mutually with their antennæ, and united once more to form one family.

They are also ever intent to promote each other's welfare, and ready to share with their absent companions any good thing they may meet with. Those that go

abroad feed those which remain in the nest; and if they discover any stock of favourite food, they inform the whole community, as we have seen above, and teach them the way to it. M. Huber, for a particular reason, having produced heat, by means of a flambeau, in a certain part of an artificial formicary, the ants that happened to be in that quarter, after enjoying it for a time, hastened to convey the welcome intelligence to their compatriots, whom they even carried suspended upon their jaws (their usual mode of transporting each other) to the spot, till hundreds might be seen thus laden with their friends.

If ants feel the force of love, they are equally susceptible of the emotions of anger; and when they are menaced or attacked, no insects show a greater degree of it. Providence, moreover, has furnished them with weapons and faculties which render it extremely formidable to their insect enemies, and sometimes, as I have related on a former occasion, a great annoyance to man himself[a]. Two strong mandibles arm their mouth, with which they sometimes fix themselves so obstinately to the object of their attack, that they will sooner be torn limb from limb than let go their hold;—and after their battles, the head of a conquered enemy may often be seen suspended to the antennæ or legs of the victor,—a trophy of his valour, which, however troublesome, he will be compelled to carry about with him to the day of his death. Their abdomen is also furnished with a poison-bag (*Ioterium*), in which is secreted a powerful and veno-

[a] Vol. I. 4th Ed. p. 122.

mous fluid, long celebrated in chemical researches, and once called *formic acid*, though now considered a modification of the *acetic* and *malic*[a]; which, when their enemy is beyond the reach of their mandibles (I speak here particularly of the hill-ant, or *F. rufa*), standing erect on their hind-legs, they ejaculate from their anus with considerable force, so that from the surface of the nest ascends a shower of poison, exhaling a strong sulphureous odour, sufficient to overpower or repel any insect or small animal. Such is the fury of some species, that with the acid, according to Gould[b], they sometimes partly eject, drawing it back however directly, the poison-bag itself. If a stick be stuck into one of the nests of the hill-ant, it is so saturated with the acid as to retain the scent for many hours. A more formidable weapon arms the species of the genus *Myrmica*, Latr.; for, besides the poison-bag, they are furnished with a sting; and their aspect is also often rendered peculiarly revolting, by the extraordinary length of their jaws, and by the spines which defend their head and trunk.

But weapons without valour are of but little use; and this is one distinguishing feature of our pygmy race. Their courage and pertinacity are unconquerable, and often sublimed into the most inconceivable rage and fury. It makes no difference to them whether they attack a mite or an elephant; and man himself instills no terror into their warlike breasts. Point your finger towards any individual of *F. rufa*,—instead of running away, it instantly faces about, and, that it may make the most of

[a] See Fourcroy, *Annales du Muséum*, no. 5. p. 338, 342. Some, however, still regard it as a distinct acid. [b] p. 34.

itself, stiffening its legs into a nearly straight line, it gives its body the utmost elevation it is capable of; and thus

"Collecting all its might dilated stands"

prepared to repel your attack. Put your finger a little nearer, it immediately opens its jaws to bite you, and rearing upon its hind-legs bends its abdomen between them, to ejaculate its venom into the wound[a].

This angry people, so well armed and so courageous, we may readily imagine are not always at peace with their neighbours; causes of dissention may arise to light the flame of war between the inhabitants of nests not far distant from each other. To these little bustling creatures a square foot of earth is a territory worth contending for;—their droves of Aphides equally valuable with the flocks and herds that cover our plains; and the body of a fly or a beetle, or a cargo of straws and bits of stick, an acquisition as important us the treasures of a Lima fleet to our seamen. Their wars are usually between nests of different species; sometimes, however, those of the same, when so near as to interfere with and incommode each other, have their battles; and with respect to ants of one species, *Myrmica rubra*, combats occasionally take place, contrary to the general habits of the tribe of ants, between those of the same nest. I shall give you some account of all these conflicts, beginning with the last. But I must first observe, that the only warriors amongst our ants are the neuters or workers; the males and females being very peaceable creatures, and always glad to get out of harm's way.

The wars of the red ant (*M. rubra*) are usually be-

[a] See Fourcroy, *Annales du Muséum*, no. 5. 343.

tween a small number of the citizens; and the object, according to Gould, is to get rid of a useless member of the community (it does not argue much in favour of the humanity of this species if it be by sickness that this member is disabled), rather than any real civil contest. "The red colonies," says this author, "are the only ones I could ever observe to feed upon their own species. You may frequently discern a party of from five or six to twenty surrounding one of their own kind, or even fraternity, and pulling it to pieces. The ant they attack is generally feeble, and of a languid complexion, occasioned perhaps by some disorder or other accident[a]." I once saw one of these ants dragged out of the nest by another, without its head; it was still alive, and could crawl about. A lively imagination might have fancied that this poor ant was a criminal, condemned by a court of justice to suffer the extreme sentence of the law. It was more probably, however, a champion that had been decapitated in an unequal combat, unless we admit Gould's idea, and suppose it to have suffered because it was an unprofitable member of the community[b]. At another time I found three individuals that were fighting with great fury, chained together by their mandibles; one of these had lost two of the legs of one side, yet it appeared to walk well, and was as eager to attack and seize its op-

[a] Gould, 104.

[b] One would think the writer of the account of ants in Mouffet had been witness to something similar. "If they see any one idle," says he, "they not only drive him as spurious, without food, from the nest; but likewise, a circle of all ranks being assembled, cut off his head before the gates, that he may be a warning to their children not to give themselves up for the future to idleness and effeminacy." —*Theatr. Ins.* 241.

ponents, as if it was unhurt. This did not look like languor or sickness.

The wars of ants that are not of the same species take place usually between those that differ in size; and the great endeavouring to oppress the small are nevertheless often outnumbered by them, and defeated. Their battles have long been celebrated, and the date of them, as if it were an event of the first importance, has been formally recorded. Æneas Sylvius, after giving a very circumstancial account of one contested with great obstinacy by a great and small species on the trunk of a pear-tree, gravely states, "This action was fought in the pontificate of Eugenius the Fourth, in the presence of Nicholas Pistoriensis, an eminent lawyer, who related the whole history of the battle with the greatest fidelity!" A similar engagement between great and small ants is recorded by Olaus Magnus, in which the small ones being victorious are said to have buried the bodies of their own soldiers, but left those of their giant enemies a prey to the birds. This event happened previous to the expulsion of the tyrant Christiern the Second from Sweden[a].

M. P. Huber is the only modern author that appears to have been witness to these combats. He tells us that, when the great attack the small, they seek to take them by surprise, (probably to avoid their fastening themselves to their legs,) and, seizing them by the upper part of the body, they strangle them with their mandibles; but when the small have time to foresee the attack, they give notice to their companions, who rush in crowds to their succour. Sometimes, however, after suffering a signal defeat, the smaller species are obliged to shift

[a] Mouffet, *Theatr. Ins.* 242.

their quarters, and to seek an establishment more out of the way of danger. In order to cover their march, many small bodies are then posted at a little distance from the nest. As soon as the large ants approach the camp, the foremost sentinels instantly fly at them with the greatest rage, a violent struggle ensues, multitudes of their friends come to their assistance, and, though no match for their enemies singly, by dint of numbers they prevail, and the giant is either slain or led captive to the hostile camp. The species whose proceedings M. Huber observed were *F. herculanea* L. and *F. sanguinea* Latr., neither of which have yet been discovered in Britain[a].

But if you would see more numerous armies engaged, and survey war in all its forms, you must witness the combats of ants of the same species, you must go into the woods where the hill-ant of Gould (*F. rufa*, L.) erects its habitations. There you will sometimes behold populous and rival cities, like Rome and Carthage, as if they had vowed each other's destruction, pouring forth their myriads by the various roads that, like rays, diverge on all sides from their respective metropolises, to decide by an appeal to arms the fate of their little world. As the exploits of frogs and mice were the theme of Homer's muse, so, were I gifted like him, might I celebrate on this occasion the exhibition of Myrmidonian valour; but, alas! I am Davus, not Œdipus; you must therefore rest contented, if I do my best in plain prose; and I trust you will not complain if, being unable to ascertain the name of any one of my heroes, my *Myrmidonomachia* be perfectly anonymous.

[a] Huber, 160.

Figure to yourself two of these cities equal in size and population, and situated about a hundred paces from each other; observe their countless numbers, equal to the population of two mighty empires. The whole space which separates them for the breadth of twenty-four inches appears alive with prodigious crowds of their inhabitants. The armies meet midway between their respective habitations, and there join battle. Thousands of champions, mounted on more elevated spots, engage in single combat, and seize each other with their powerful jaws; a still greater number are engaged on both sides in taking prisoners, which make vain efforts to escape, conscious of the cruel fate which awaits them when arrived at the hostile formicary. The spot where the battle most rages is about two or three square feet in dimensions: a penetrating odour exhales on all sides,—numbers of ants are here lying dead covered with venom,—others, composing groups and chains, are hooked together by their legs or jaws, and drag each other alternately in contrary directions. These groups are formed gradually. At first a pair of combatants seize each other, and rearing upon their hind-legs mutually spirt their acid, then closing they fall and wrestle in the dust. Again recovering their feet, each endeavours to drag off his antagonist. If their strength be equal, they remain immoveable, till the arrival of a third gives one the advantage. Both, however, are often succoured at the same time, and the battle still continues undecided—others take part on each side, till chains are formed of six, eight, or sometimes ten, all hooked together and struggling pertinaciously for the mastery: the equilibrium remains unbroken, till a number of champions from the

same nest arriving at once, compel them to let go their hold, and the single combats recommence. At the approach of night, each party gradually retreats to its own city: but before the following dawn the combat is renewed with redoubled fury, and occupies a greater extent of ground. These daily fights continue till, violent rains separating the combatants, they forget their quarrel, and peace is restored.

Such is the account given by M. Huber of a battle he witnessed. In these engagements, he observes, their fury is so wrought up, that nothing can divert them from their purpose. Though he was close to them examining their proceedings, they paid not the least attention to him, being absorbed by one sole object, that of finding an enemy to attack. What is most wonderful in this history, though all are of the same make, colour, and scent, every ant seemed to know those of his own party; and if by mistake one was attacked, it was immediately discovered by the assailant, and caresses succeeded to blows. Though all was fury and carnage in the space between the two nests, on the other side the paths were full of ants going to and fro on the ordinary business of the society, as in a time of peace; and the whole formicary exhibited an appearance of order and tranquillity, except that on the quarter leading to the field of battle crowds might always be seen, either marching to reinforce the army of their compatriots, or returning home with the prisoners they had taken[a], which it is to be feared are the devoted victims of a cannibal feast.

Having, I apprehend, satiated you with the fury and

[a] See Huber, chap. v.

carnage of Myrmidonian wars, I shall next bring forward a scene still more astonishing, which at first, perhaps, you will be disposed to regard as the mere illusion of a lively imagination. What will you say when I tell you that certain ants are affirmed to sally forth from their nests on predatory expeditions, for the singular purpose of procuring *slaves* to employ in their domestic business; and that these ants are usually a ruddy race, while their slaves themselves are black? I think I see you here throw down my letter and exclaim—"What! ants turned slave-dealers! This is a fact so extraordinary and improbable, and so out of the usual course of nature, that nothing but the most powerful and convincing evidence shall induce me to believe it." In this I perfectly approve your caution; such a solecism in nature ought not to be believed till it has undergone the ordeal of a most thorough investigation. Unfortunately in this country we have not the means of satisfying ourselves by ocular demonstration, since none of the slave-dealing ants appear to be natives of Britain. We must be satisfied, therefore, with weighing the evidence of others. Hear what M. P. Huber, the discoverer of this almost incredible deviation of nature from her general laws, has advanced to convince the world of the accuracy of his statement, and you will, I am sure, allow that he has thrown over his history a colouring of verisimilitude, and that his appeal to testimony is in a very high degree satisfactory.

"My readers," says he, "will perhaps be tempted to believe that I have suffered myself to be carried away by the love of the marvellous, and that, in order to impart greater interest to my narration, I have given way to an inclination to embellish the facts that I have observed.

But the more the wonders of nature have attractions for me, the less do I feel inclined to alter them by a mixture of the reveries of imagination. I have sought to divest myself of every illusion and prejudice, of the ambition of saying new things, of the prepossessions often attached to perceptions too rapid, the love of system, and the like. And I have endeavoured to keep myself, if I may so say, in a disposition of mind perfectly neuter, and ready to admit all facts, of whatever nature they might be, that patient observation should confirm. Amongst the persons whom I have taken as witnesses to the discovery of mixed ant-hills, I can cite a distinguished philosopher (Prof. Jurine) who was desirous of verifying their existence by examining himself the two species united[a]."

He afterwards appeals to nature, and calls upon all who doubt to repeat his experiments, which he is sure will soon satisfy them:—a satisfaction which, as I have just observed, in this country we cannot receive, for want of the slave-making species. And now to begin my history.

There are two species of ants which engage in these excursions, *F. rufescens* and *F. sanguinea*, Latr.: but they do not, like the African kings, make slaves of adults, their sole object being to carry off the helpless infants of the colony which they attack, the larvæ and pupæ; these they educate in their own nests, till they arrive at their perfect state, when they undertake all the business of the society[b].

[a] Huber, 287. Jurine, *Hyménoptères*, 273.

[b] It is not clear that our Willughby had not some knowledge of this extraordinary fact; for in his description of ants, speaking of their care of their pupæ, he says, "*that they also carry the aureliæ of others into their nests, as if they were their own.*" Rai. *Hist. Ins.* 69.—Gould remarks concerning the hill-ant, "This species is very rapacious

In the following account I shall chiefly confine myself to what Huber relates of the first of these species, and conclude my extracts with his history of an expedition of the latter to procure slaves.

The rufescent ants[a] do not leave their nests to go upon these expeditions, which last about ten weeks, till the males are ready to emerge into the perfect state: and it is very remarkable, that if any individuals attempt to stray abroad earlier, they are detained by their slaves, who will not suffer them to proceed. A wonderful provision of the Creator to prevent the black colonies from being pillaged when they contain only male and female brood, which would be their total destruction, without being any benefit to their assailants, to whom neuters alone are useful.

Their time of sallying forth is from two in the afternoon till five, but more generally a little before five: the weather, however, must be fine, and the thermometer must stand at above 36° in the shade. Previously to marching there is reason to think that they send out scouts to explore the vicinity; upon whose return they emerge from their subterranean city, directing their course to the quarter from which the scouts came. They have various preparatory signals, such as pushing each other with the mandibles or forehead, or playing with the antennæ, the ob-

after the *vermicles* and *nymphs* of other ants. If you place a parcel before or near their colonies, they will, with remarkable greediness, seize and carry them off." 91, note *. Query—Do they this to devour them, or educate them? White made the same observation, *Nat. Hist.* ii. 278.

[a] This species forms a kind of link which connects Latreille's two genera *Formica* and *Myrmica*, borrowing the abdominal squama from the former, and the sting from the latter.

ject of which is probably to excite their martial ardour, to give the word for marching, or to indicate the route they are to take. The advanced guard usually consists of eight or ten ants; but no sooner do these get beyond the rest, than they move back, wheeling round in a semicircle, and mixing with the main body, while others succeed to their station. They have "*no captain, overseer, or ruler*," as Solomon observes, their army being composed entirely of neuters, without a single female: thus all in their turns take their place at the head, and then retreating towards the rear, make room for others. This is the usual order of their march; and the object of it may be to communicate intelligence more readily from one part of the column to another.

When winding through the grass of a meadow they have proceeded to thirty feet or more from their own habitation, they disperse; and, like dogs with their noses, explore the ground with their antennæ to detect the traces of the game they are pursuing. The negro formicary, the object of their search, is soon discovered; some of the inhabitants are usually keeping guard at the avenues, which dart upon the foremost of their assailants with inconceivable fury. The alarm increasing, crowds of its swarthy inhabitants rush forth from every apartment; but their valour is exerted in vain; for the besiegers, precipitating themselves upon them, by the ardour of their attack compel them to retreat within, and seek shelter in the lowest story; great numbers entering with them at the gates, while others with their mandibles make a breach in the walls, through which the victorious army marches into the besieged city. In a few minutes, by the same passages, they as hastily

evacuate it, each carrying off in its mouth a larva or pupa which it has seized in spite of its unhappy guardians. On their return home with their spoil, they pursue exactly the route by which they went to the attack. Their success on these expeditions is rather the result of their impetuosity, by which they damp the courage of the negroes, than of their superior strength, though they are a larger animal; for sometimes a very small body of them, not more than 150, has been known to succeed in their attack and to carry off their booty[a].

[a] Since the publication of the first edition of this volume I have met with fresh confirmation of the extraordinary history here related. Having been induced to visit Paris this summer, and calling upon M. Latreille (so justly celebrated as one of the first entomologists of the age, and to whom I feel infinitely indebted for the friendly attentions which he paid to me during my too short stay in that metropolis), he assured me, that he had verified all the principal facts advanced by Huber. He has also said the same in his *Considérations nouvelles et générales sur les insectes vivant en Societé*. (Mém. du Mus. iii. 407.) At the same time he informed me that there was a nest of the rufescent ants in the Bois de Boulogne, to which place he afterwards was so good as to accompany me. We went on the 25th of June. The day was excessively hot and sultry. A little before five in the afternoon we began our search. At first we could not discern a single ant in motion. In a minute or two, however, my friend directed my attention to one individual—two or three more next appeared—and soon a numerous army was to be seen winding through the long grass of a low ridge in which was their formicary. Just at the entrance of the wood from Paris, on the right-hand and near the road, is a bare place paled in for the Sunday amusement of the lower orders—to this the ants directed their march, and upon entering it divided into two columns, which traversed it rapidly and with great apparent eagerness; all the while exploring the ground with their antennæ as beagles with their noses, evidently as if in pursuit of game. Those in the van, as Huber also observed, kept perpetually falling back into the main body. When they had passed this inclosure, they appeared for some time to be at a loss, making no progress but only coursing about: but after a few

When from their proximity they are more readily to be come at than those of the negroes, they sometimes assault with the same view the nest of another species of ant, which I shall call the miners (*F. cunicularia*, L.). This species being more courageous than the other, on this account the rufescent host marches to the attack in closer order than usual, moving with astonishing rapidity. As soon as they begin to enter their habitation, myriads of the miners rushing out fall upon them with great fury; while others, well aware of their purpose,

minutes delay, as if they had received some intelligence, they resumed their march and soon arrived at a negro nest, which they entered by one or two apertures. We could not observe that any negroes were expecting their attack outside the nest, but in a short time a few came out at another opening, and seemed to be making their escape. Perhaps some conflict might have taken place within the nest, in the interval between the appearance of these negroes and the entry of their assailants. However this might be, in a few minutes one of the latter made its appearance with a pupa in its mouth; it was followed by three or four more; and soon the whole army began to emerge as fast as it could, almost every individual carrying its burthen. Most that I observed seemed to have pupæ. I then traced the expedition back to the spot from which I first saw them set out, which according to my steps was about 156 feet from the negro formicary. The whole business was transacted in little more than an hour. Though I could trace the ants back to a certain spot in the ridge before mentioned, where they first appeared in the long grass, I did not succeed in finding the entrance to their nest, so that I was deprived of the pleasure of seeing the mixed society. As we dined at an *auberge* close to the spot, I proposed renewing my researches after dinner; but a violent tempest of thunder and rain, though I attempted it, prevented my succeeding; and afterwards I had no opportunity of revisiting the place.

M. Latreille very justly observes that it is physically impossible for the *rufescent* ants, on account of the form of their jaws and the accessory parts of the mouth, either to prepare habitations for their family, to procure food, or to feed them.—*Considérations nouvelles, &c.* p. 408.

making a passage through the midst of them, carry off in their mouth the larvæ and pupæ. The surface of the nest thus becomes the scene of an obstinate conflict, and the assailants are often deprived of the prey which they had seized. The miners dart upon them, fight them foot to foot, dispute every inch of their territory, and defend their progeny with unexampled courage and rage. When the rufescents, laden with pillage, retire, they do it in close order—a precaution highly necessary, since their valiant enemies, pursuing them, impede their progress for a considerable distance from their residence.

During these combats the pillaged ant-hill presents in miniature the spectacle of a besieged city; hundreds of its inhabitants may be seen making their escape, and carrying off in different directions, to a place of security, some the young brood, and others their females that are newly excluded: but when the danger is wholly passed, they bring them back to their city, the gates of which they barricade, and remain in great numbers near them to guard the entrance.

Formica sanguinea, as I observed above, is another of the slave-making ants; and its proceedings merit separate notice, since they differ considerably from those of the rufescents. They construct their nests under hedges of a southern aspect, and likewise attack the hills both of the negroes and miners. On the 15th of July, at ten in the morning, Huber observed a small band of these ants sallying forth from their formicary, and marching rapidly to a neighbouring nest of negroes, around which it dispersed. The inhabitants, rushing out in crowds, attacked them and took several prisoners: those that escaped advanced no further, but appeared to wait for

succours; small brigades kept frequently arriving to reinforce them, which emboldened them to approach nearer to the city they had blockaded; upon this their anxiety to send couriers to their own nest seemed to increase: these spreading a general alarm, a large reinforcement immediately set out to join the besieging army; yet even then they did not begin the battle. Almost all the negroes, coming out of their fortress, formed themselves in a body about two feet square in front of it, and there expected the enemy. Frequent skirmishes were the prelude to the main conflict, which was begun by the negroes. Long before success appeared dubious they carried off their pupæ, and heaped them up at the entrance to their nest, on the side opposite to that on which the enemy approached. The young females also fled to the same quarter. The sanguine ants at length rush upon the negroes, and attacking them on all sides, after a stout resistance the latter, renouncing all defence, endeavour to make off to a distance with the pupæ they have heaped up:—the host of assailants pursues, and strives to force from them these objects of their care. Many also enter the formicary, and begin to carry off the young brood that are left in it. A continued chain of ants engaged in this employment extends from nest to nest, and the day and part of the night pass before all is finished. A garrison being left in the captured city, on the following morning the business of transporting the brood is renewed. It often happens (for this species of ant loves to change its habitation) that the conquerors emigrate with all their family to the acquisition which their valour has gained. All the incursions of *F. sanguinea* take place in the space of a month, and they

make only five or six in the year. They will sometimes travel 150 paces to attack a negro colony.

After reading this account of expeditions undertaken by ants for so extraordinary a purpose, you will be curious to know how the slaves are treated in the nests of these marauders—whether they live happily, or labour under an oppressive yoke. You must recollect that they are not carried off, like our negroes, at an age when the *amor patriæ* and all the charities of life which bind them to their country, kindred and friends, are in their full strength, but in what may be called the helpless days of infancy, or in their state of repose, before they can have formed any associations or imbibed any notions that render one place and society more dear to them than another. Preconceived ideas, therefore, do not exist to influence their happiness, which must altogether depend upon the treatment which they experience at the hands of their new masters. Here the goodness of Providence is conspicuous; which, although it has gifted these creatures with an instinct so extraordinary, and seemingly so unnatural, has not made it a source of misery to the objects of it.

You will here, perhaps, imagine that I have not sufficiently taken into consideration the anxiety and privations undergone by the poor neuters, in beholding those foster-children, for which they have all along manifested such tender solicitude, thus violently snatched from them: but when you reflect that they are the common property of the whole colony, and that, consequently, there can scarcely be any separate attachment to particular individuals, you will admit that, after the fright and horror of the conflict are over, and their enemies have retreated,

they are not likely to experience the poignant affliction felt by parents when deprived of their children; especially when you further consider, that most probably some of their brood are rescued from the general pillage; or at any rate their females are left uninjured, to restore the diminished population of their colonies, and to supply them with those objects of attention, the larvæ, &c. so necessary to that development of their instincts in which consists their happiness.

But to return to the point from which I digressed— The negro and miner ants suffer no diminution of happiness, and are exposed to no unusual hardships and oppression in consequence of being transplanted into a foreign nest. Their life is passed in much the same employments as would have occupied it in their native residence. They build or repair the common dwelling; they make excursions to collect food; they attend upon the females; they feed them and the larvæ; and they pay the necessary attention to the daily sunning of the eggs, larvæ, and pupæ. Besides this, they have also to feed their masters and to carry them about the nest. This you will say is a serious addition to the ordinary occupations of their own colonies: but when you consider the greater division of labour in these mixed societies, which sometimes unite both negroes and miners in the same dwelling, so that three distinct races live together, from their vast numbers so far exceeding those of the native nest, you will not think this too severe employment for so industrious an animal.

But you will here ask, perhaps—"Do the masters take no part in these domestic employments? At least, surely, they direct their slaves, and see that they keep to their

work?"—No such thing, I assure you—the sole motive for their predatory excursions seems to be mere laziness and hatred of labour. Active and intrepid as they are in the field, at all other times they are the most helpless animals that can be imagined;—unwilling to feed themselves, or even to walk, their indolence exceeds that of the sloth itself. So entirely dependent, indeed, are they upon their negroes for every thing, that upon some occasions the latter seem to be the masters, and exercise a kind of authority over them. They will not suffer them, for instance, to go out before the proper season, or alone; and if they return from their excursions without their usual booty, they give them a very indifferent reception, showing their displeasure, which however soon ceases, by attacking them; and when they attempt to enter the nest, dragging them out. To ascertain what they would do when obliged to trust to their own exertions, Huber shut up thirty of the rufescent ants in a glazed box, supplying them with larvæ and pupæ of their own kind, with the addition of several negro pupæ, excluding very carefully all their slaves, and placing some honey in a corner of their prison. Incredible as it may seem, they made no attempt to feed themselves: and though at first they paid some attention to their larvæ, carrying them here and there, as if too great a charge they soon laid them down again; most of them died of hunger in less than two days; and the few that remained alive appeared extremely weak and languid. At length, commiserating their condition, he admited a single negro; and this little active creature by itself re-established order—made a cell in the earth; collected the larvæ and placed them in it; assisted the pupæ that were ready to be developed;

and preserved the life of the neuter rufescents that still survived. What a picture of beneficent industry, contrasted with the baleful effects of sloth, does this interesting anecdote afford! Another experiment which he tried made the contrast equally striking. He put a large portion of one of these mixed colonies into a woollen bag, in the mouth of which he fixed a small tube of wood, glazed at the top, which at the other end was fitted to the entrance of a kind of hive. The second day the tube was crowded with negroes going and returning:—the indefatigable diligence and activity manifested by them in transporting the young brood and their rufescent masters, whose bodies were suspended upon their mandibles, was astonishing. These last took no active part in the busy scene, while their slaves showed the greatest anxiety about them, generally carrying them into the hive; and if they sometimes contented themselves with depositing them at the entrance of the tube, it was that they might use greater dispatch in fetching the rest. The rufescent when thus set down remained for a moment coiled up without motion, and then leisurely unrolling itself, looked all around, as if it was quite at a loss what direction to take;—it next went up to the negroes, and by the play of its antennæ seemed to implore their succour, till one of them attending to it conducted it into the hive.

Beings so entirely dependent, as these masters are upon their slaves, for every necessary, comfort, and enjoyment of their life, can scarcely be supposed to treat them with rigour or unkindness:—so far from this, it is evident from the preceding details, that they rather look up to them, and are in some degree under their control.

The above observations, with respect to the indolence

of our slave-dealers, relate principally to the *rufescent* species; for the *sanguine* ants are not altogether so listless and helpless; they assist their negroes in the construction of their nests, they collect their sweet fluid from the Aphides; and one of their most usual occupations is to lie in wait for a small species of ant, on which they feed; and when their nest is menaced by an enemy, they show their value for these faithful servants by carrying them down into the lowest apartments, as to a place of the greatest security. Sometimes even the rufescents rouse themselves from the torpor that usually benumbs them. In one instance, when they wished to emigrate from their own to a deserted nest, they reversed what usually takes place on such occasions, and carried all their negroes themselves to the spot they had chosen. At the first foundation also of their societies by impregnated females, there is good reason for thinking, that, like those of other species[a], they take upon themselves the whole charge of the nascent colony. I must not here omit a most extraordinary anecdote related by M. Huber. He put into one of his artificial formicaries pupæ of both species of the slave-collecting ants, which, under the care of some negroes introduced with them, arrived at their imago state, and lived together under the same roof in the most perfect amity.

These facts show what effects education will produce even upon insects; that it will impart to them a new bias, and modify in some respects their usual instincts, rendering them familiar with objects which, had they been educated at home, they would have feared, and causing

[a] Vol. I. 4th Ed. 369.

them to love those whom in that case they would have abhorred.—It occasions, however, no further change in their character, since the master and slave, brought up with the same care and under the same superintendence, are associated in the mixed formicary under laws entirely opposite[b].

Unparalleled and unique in the animal kingdom as this history may appear, you will scarcely deem the next I have to relate less singular and less worthy of admiration. That ants should have their *milch cattle* is as extraordinary as that they should have slaves. Here, perhaps, you may again feel a fit of incredulity shake you;—but the evidence for the fact I am now stating being abundant and satisfactory, I flatter myself it will not shake you long.

The loves of the ants and the aphides (for these last are the kine in question) have long been celebrated; and that there is a connexion between them you may at any time, in the proper season, convince yourself; for you will always find the former very busy on those trees and plants on which the latter abound: and if you examine more closely, you will discover that their object in thus attending upon them is to obtain the saccharine fluid, which may well be denominated their milk[b], that they secrete.

This fluid, which is scarcely inferior to honey in sweetness, issues in limpid drops from the abdomen of these insects, not only by the ordinary passage, but also by two setiform tubes placed, one on each side, just above

[a] See Huber, chap. vii—xi.

[b] The ant ascends the tree, says Linné, *that it may milk its cows, the Aphides*, not kill them. *Syst. Nat.* 962. 3.

it. Their sucker being inserted in the tender bark, is without intermission employed in absorbing the sap, which, after it has passed through the system, they keep continually discharging by these organs. When no ants attend them, by a certain jerk of the body, which takes place at regular intervals, they ejaculate it to a distance: but when the ants are at hand, watching the moment when the aphides emit their fluid, they seize and suck it down immediately. This, however, is the least of their talents; for they absolutely possess the art of making them yield it at their pleasure; or, in other words, of milking them. On this occasion their antennæ are their fingers; with these they pat the abdomen of the aphis on each side alternately, moving them very briskly; a little drop of fluid immediately appears, which the ant takes into its mouth, one species (*Myrmica rubra*) conducting it with its antennæ, which are somewhat swelled at the end. When it has thus milked one, it proceeds to another, and so on, till being satiated it returns to the nest.

Not only the aphides yield this repast to the ants, but also the *Cocci*, with whom they have recourse to similar manœuvres, and with equal success; only in this case the movement of the antennæ over their body may be compared to the thrill of the finger over the keys of a piano-forte.

But you are not arrived at the most singular part of this history,—that ants make a *property* of these cows, for the possession of which they contend with great earnestness, and use every means to keep them to themselves. Sometimes they seem to claim a right to the aphides that inhabit the branches of a tree or the stalks of a plant;

and if stranger-ants attempt to share their treasure with them, they endeavour to drive them away, and may be seen running about in a great bustle, and exhibiting every symptom of inquietude and anger. Sometimes, to rescue them from their rivals, they take their aphides in their mouth, they generally keep guard round them, and when the branch is conveniently situated, they have recourse to an expedient still more effectual to keep off interlopers,—they inclose it in a tube of earth or other materials, and thus confine them in a kind of paddock near their nest, and often communicating with it.

The greatest cow-keeper of all the ants, is one to be met with in most of our pastures, residing in hemispherical formicaries, which are sometimes of considerable diameter. I mean the yellow ant of Gould (*F. flava*). This species, which is not fond of roaming from home, and likes to have all its conveniences within reach, usually collects in its nest a large herd of a kind of Aphis, that derives its nutriment from the roots of grass and other plants (*Aphis radicum*); these it transports from the neighbouring roots, probably by subterranean galleries, excavated for the purpose, leading from the nest in all directions[a]; and thus, without going out, it has always at hand a copious supply of food. These creatures share its care and solicitude equally with its own offspring. To the eggs it pays particular attention, moistening them with its tongue, carrying them in its mouth with the utmost tenderness, and giving them the advantage of the sun. This last fact I state from my own observation; for once upon opening one of these ant-hills early in the

[a] Huber, 195. I have more than once found these Aphides in the nests of this species of ant.

spring, on a sunny day, I observed a parcel of these eggs, which I knew by their black colour, very near the surface of the nest. My attack put the ants into a great ferment, and they immediately began to carry these interesting objects down into the interior of the nest. It is of great consequence to them to forward the hatching of these eggs as much as possible, in order to ensure an early source of food for their colony; and they had doubtless in this instance brought them up to the warmest part of their dwelling with this view. M. Huber, in a nest of the same ant, at the foot of an oak, once found the eggs of *Aphis Quercûs*, L.

Our yellow ants are equally careful of their Aphides after they are hatched, when their nest is disturbed conveying them into the interior, fighting fiercely for them if the inhabitants of neighbouring formicaries, as is sometimes the case, attempt to make them their prey; and carrying them about in their mouths to change their pasture, or for some other purpose. When you consider that from them they receive almost the whole nutriment both of themselves and larvæ, you will not wonder at their anxiety about them, since the wealth and prosperity of the community is in proportion to the number of their cattle. Several other species keep Aphides in their nests, but none in such numbers as those of which I am speaking[a].

When the population exceeds the produce of a country, or its inhabitants suffer oppression, or are not com-

[a] See Huber, chap, vi. I have found Aphides in the nest of *Myrmica rubra*. Boisier de Sauvages speaks of ants keeping their own Aphides, and gives an interesting account of them. *Journ. de Physique*, i. 195.

fortable in it, emigrations frequently take place, and colonies issue forth to settle in other parts of the globe; and sometimes whole nations leave their own country, either driven to this step by their enemies, or excited by cupidity to take possession of what appears to them a more desirable residence. These motives operate strongly on some insects of the social tribes.—Bees and ants are particularly influenced by them. The former, confined in a narrow hive, when their society becomes too numerous to be contained conveniently in it, must necessarily send forth the redundant part of their population to seek for new quarters; and the latter—though they usually can enlarge their dwelling to any dimensions which their numbers may require, and therefore do not send forth colonies, unless we may distinguish by that name the departure of the males and females from the nest—are often disgusted with their present habitation, and seek to establish themselves in a new one:—either the near neighbourhood of enemies of their own species; annoyance from frequent attacks of man or other animals; their exposure to cold or wet from the removal of some species of shelter; or the discovery of a station better circumstanced or more abundant in aphides;—all these may operate as inducements to them to change their residence. That this is the case might be inferred from the circumstance noticed by Gould[a], which I have also partly witnessed myself, that they sometimes transport their young brood to a considerable distance from their home. But M. Huber, by his interesting observations, has placed this fact beyond all controversy; and his history of their emigrations is enlivened by some traits so singular, that I am impatient to

[a] Gould, 42.

relate them to you. They concern chiefly the great hill-ant (*F. rufa*), though several other species occasionally emigrate.

Some of the neuters having found a spot which they judge convenient for a new habitation, apparently without consulting the rest of the society, determine upon an emigration, and thus they compass their intention: The first step is to raise recruits:—with this view they eagerly accost several fellow citizens of their own order, caress them with their antennæ, lead them by their mandibles, and evidently appear to propose the journey to them. If they seem disposed to accompany them, the recruiting officer, for so it may be called, prepares to carry off his recruit, who, suspending himself upon his mandibles, hangs coiled up spirally under his neck;—all this passes in an amicable manner after mutual salutations. Sometimes, however, the recruiter takes the other by surprise, and drags him from the ant-hill without giving him time to consider or resist. When arrived at the proposed habitation, the suspended ant uncoils itself, and, quitting its conductor, becomes a recruiter in its turn. The pair return to the old nest, and each carries off a fresh recruit, which being arrived at the spot joins in the undertaking:—thus the number of recruiters keeps progressively increasing, till the path between the new and the old city is full of goers and comers, each of the former laden with a recruit. What a singular and amusing scene is then exhibited of the little people thus employed! When an emigration of a rufescent colony is going forward, the negroes are seen carrying their masters: and the contrast of the red with the black renders it peculiarly striking. The little turf-ants (*F. cæspitum*, L.) upon these occasions carry

their recruits uncoiled, with their head downwards and their body in the air.

This extraordinary scene continues several days; but when all the neuters are acquainted with the road to the new city, the recruiting ceases. As soon as a sufficient number of apartments to contain them are prepared, the young brood, with the males and females, are conveyed thither, and the whole business is concluded. When the spot thus selected for their residence is at a considerable distance from the old nest, the ants construct some intermediate receptacles, resembling small ant-hills, consisting of a cavity filled with fragments of straw and other materials, in which they form several cells; and here at first they deposit their recruits, males, females, and brood, which they afterwards conduct to the final settlement. These intermediate stations sometimes become permanent nests, which however maintain a connexion with the capital city[a].

While the recruiting is proceeding, it appears to occasion no sensation in the original nest; all goes on in it as usual, and the ants that are not yet recruited pursue their ordinary occupations: whence it is evident that the change of station is not an enterprise undertaken by the whole community. Sometimes many neuters set about this business at the same time, which gives a short existence (for in the end they all reunite into one) to many separate formicaries. If the ants dislike their new city, they quit it for a third, and even for a fourth: and what is re-

[a] Walking one day early in July, this summer (1815), in a spot where I used to notice a single nest of *Formica rufa*, I observed that a new colony had been formed of considerable magnitude; and between it and the original nest were six or seven smaller settlements.

markable, they will sometimes return to their original one before they are entirely settled in the new station; when the recruiting goes in opposite directions, and the pairs pass each other on the road. You may stop the emigration for the present, if you can arrest the first recruiter, and take away his recruit[a].

I shall now relate to you some other portions of Myrmidonian History, which, though perhaps not so striking and wonderful as the preceding details, are not devoid of interest, and will serve to exemplify their incredible diligence, labour, and ingenuity.

In this country it is commonly in March, earlier or later according to the season, that ants first make their appearance, and they continue their labours till the middle or latter end of October. They emerge usually from their subterranean winter-quarters on some sunny day; when, assembling in crowds on the surface of the formicary, they may be observed in continual motion, walking incessantly over it and one another, without departing from home; as if their object, before they resumed their employments, was to habituate themselves to the action of the air and sun[b]. This preparation requires a few days, and then the business of the year commences. The earliest employment of ants is most probably to repair the injuries which their habitation has received during their state of inactivity: this observation more particularly applies to the hill-ant (*F. rufa*), all the upper stories of whose dwellings are generally laid flat by the winter rains and snow; but every species, it may well be supposed, has at this season some deranged

[a] See Huber, chap. iv. § 3. [b] Gould, 67. De Geer, ii. 1054.

apartments to restore to order, or some demolished ones to rebuild.

After their annual labours are begun, few are ignorant how incessantly ants are engaged in building or repairing their habitations, in collecting provisions, and in the care of their young brood; but scarcely any are aware of the extent to which their activity is carried, and that their labours are going on even in the night.—Yet this is a certain fact.—Long ago Aristotle affirmed that ants worked in the night when the moon was at the full[a]; and their historian Gould observes, "that they even exceed the painful industrious bees. For the ants employ each moment, by day and night, almost without intermission, unless hindered by excessive rains[b]." M. Huber also, speaking of a mason-ant, not found with us, tells us that they work after sun-set, and in the night[c]. To these I can add some observations of my own, which fully confirm these accounts. My first were made at nine o'clock at night, when I found the inhabitants of a nest of the red ant (*Myrmica rubra*) very busily employed; I repeated the observation, which I could conveniently do, the nest being in my garden, at various times from that hour till twelve, and always found some going and coming, even while a heavy rain was falling. Having in the day noticed some Aphides upon a thistle, I examined it again in the night, at about eleven o'clock, and found my ants busy milking their cows, which did not for the sake of repose intermit their suction. At the same hour, another night, I observed the little negro ant (*F. fusca*) engaged in the same employment upon an

[a] *Hist. Animal.* l. ix. c. 38. [b] Gould, 68. [c] Huber, 35, 42.

elder. About two miles from my residence was a nest of Gould's hill-ant (*F. rufa*), which, according to M. Huber, shut their gates, or rather barricade them, every night, and remain at home[a]. Being desirous of ascertaining the accuracy of his statement, early in October, about two o'clock one morning, I visited this nest, in company with an intelligent friend; and to our surprise and admiration we found our ants at work, some being engaged in carrying their usual burthen, sticks and straws, into their habitation, others going out from it, and several were climbing the neighbouring oaks, doubtless to milk their Aphides. The number of comers and goers at that hour, however, was nothing compared with the myriads that may always be seen on these nests during the day. It so happened that our visit was paid while the moon was near the full; so that whether this species is equally vigilant and active in the absence of that luminary yet remains uncertain. Perhaps this circumstance might reconcile Huber's observation with ours, and confirm the accuracy of Aristotle's statement before quoted. To the *red ant*, indeed, it is perfectly indifferent whether the moon shine or not; they are always busy, though not in such numbers as during the day. It is probable that these creatures take their repose at all hours indifferently; for it cannot be supposed that they are employed day and night without rest.

I have related to you in this and former letters most of the works and employments of ants, but as yet I have given you no account of their roads and track-ways.—

[a] Huber, 23.

Don't be alarmed, and imagine I am going to repeat to you the fable of the ancients, that they wear a path in the stones[a]; for I suppose you will scarcely be brought to believe that, as Hannibal cut a way for the passage of his army over the Alps by means of vinegar, so the ants may with equal effect employ the formic acid: but more species than one do really form roads which lead from their formicaries into the adjoining country. Gould, speaking of his jet-ant (*F. fuliginosa*), says that they make several main track-ways, (streets he calls them,) with smaller paths striking off from them, extending sometimes to the distance of forty feet from their nest, and leading to those spots in which they collect their provisions; that upon these roads they always travel, and are very careful to remove from them bits of sticks, straw, or any thing that may impede their progress; nay, that they even keep low the herbs and grass which grow in them, by constantly biting them off[b], so that they may be said to mow their walks. But the best constructors of roads are the hill-ants (*F. rufa*). Of these De Geer says, "When you keep yourself still, without making any noise, in the woods peopled with these ants, you may hear them very distinctly walking over the dry leaves which are dispersed upon the soil, the claws of their feet producing a slight sound when they lay hold of them. They make in the ground broad paths, well beaten, which may be readily distinguished, and which are formed by the going and coming of innumerable ants, whose custom it is always to travel in the same route[c]."

[a] Plin. *Hist. Nat.* lxi. c. 29. [b] Gould, 87. [c] De Geer, ii. 1067.

From Huber we further learn, that these roads of the hill-ants are sometimes a hundred feet in length, and several inches wide; and that they are not formed merely by the tread of these creatures, but hollowed out by their labour[a]. Virgil alludes to their tracks in the following animated lines, which, though not altogether correct, are very beautiful:

"So when the pismires, an industrious train,
Embodied rob some golden heap of grain,
Studious ere stormy winter frowns to lay
Safe in their darksome cells the treasured prey;
In one long track the dusky legions lead
Their prize in triumph through the verdant mead;
Here bending with the load, a panting throng
With force conjoin'd heave some huge grain along;
Some lash the stragglers to the task assign'd,
Some to their ranks the bands that lag behind:
They crowd *the peopled path* in thick array,
Glow at the work, and darken all the way."

Bonnet, observing that ants always keep the same track both in going from and returning to their nest, imagines that their paths are imbued with the strong scent of the formic acid, which serves to direct them; but, as Huber remarks, though this may be of some use to them, their other senses must be equally employed, since it is evident, when they have made any discovery of agreeable food, that they posses the means of directing their companions to it, though it is scarcely possible that the path can have been sufficiently impregnated with the acid for them to trace their way to it by scent. Indeed the recruiting system described above, proves that it requires some

[a] Huber, 146.

pains to instruct ants in the way from an old to a new nest; whereas, were they directed by scent, after a sufficient number had passed to and fro to imbue the path with the acid, there would be no occasion for further deportations[a].

Though ants have no mechanical inventions to diminish the quantum of labour, yet by numbers, strength, and perseverance they effect what at first sight seems quite beyond their powers. Their strength is wonderful: I once, as I formerly observed, saw two or three of them haling along a young snake not dead, which was of the thickness of a goose-quill[b]. St. Pierre relates, that he was highly amused with seeing a number of ants carrying off a Patagonian centipede. They had seized it by all its legs, and bore it along as workmen do a large piece of timber[c]. The Mahometans hold, as Thevenot relates, that one of the animals in Paradise is Solomon's ant, which, when all creatures in obedience to him brought him presents, dragged before him a locust, and was therefore preferred before all others, because it had brought a creature so much bigger than itself. They sometimes, indeed, aim at things beyond their strength; but if they make their attack, they pertinaciously persist in it though at the expense of their lives. I have in my cabinet a specimen of *Colliuris longicollis*, Latr., to one of the legs of which a small ant, scarcely a thirtieth part of its bulk, is fixed by its jaws. It had probably the audacity to attack this giant, compared with itself, and

[a] *Œuv. de* Bonnet, i. 535. Huber, 197. [b] Vol. I. 4th Ed. 255.
[c] *Voy. to Maurit.* 71.

obstinately refusing to let go its hold was starved to death[a]. Professor Afzelius once related to me some particulars with respect to a species of ant in Sierra Leone, which proves the same point. He says that they march in columns that exceed all powers of numeration, and always pursue a straight course, from which nothing can cause them to deviate: if they come to a house or other building, they storm or undermine it; if a river comes across them, though millions perish in the attempt, they endeavour to swim over it.

This quality of perseverance in ants on one occasion led to very important results, which affected a large portion of this habitable globe; for the celebrated conqueror Timour, being once forced to take shelter from his enemies in a ruined building, where he sat alone many hours, desirous of diverting his mind from his hopeless condition, he fixed his observation upon an ant that was carrying a grain of corn (probably a pupa) larger than itself up a high wall. Numbering the efforts that it made to accomplish this object, he found that the grain fell sixty-nine times to the ground, but the seventieth time it reached the top of the wall. "This sight (said Timour) gave me courage at the moment; and I have never forgotten the lesson it conveyed[b]."

Madame Merian, in her *Surinam Insects*, speaking of the large-headed ant (*Formica megacephala*, L.), affirms

[a] I was much amused, when dining in the forest of Fontainebleau this summer, by the pertinacity with which the hill-ant (*F. rufa*) attacked our food, haling from our very plates, while we were eating, long strips of meat many times their own size.

[b] Related in the *Quarterly Review* for August 1816, p. 259.

that, if they wish to emigrate, they will construct a living bridge in this manner:—One individual first fixes itself to a piece of wood by means of its jaws, and remains stationary; with this a second connects itself; a third takes hold of the second, and a fourth of the third, and so on, till a long connected line is formed fastened at one extremity, which floats exposed to the wind, till the other end is blown over so as to fix itself to the opposite side of the stream, when the rest of the colony pass over upon it, as a bridge[a]. This is the process, as far as I can collect it from her imperfect account:—as she is not always very correct in her statements, I regarded this as altogether fabulous, till I met with the following history of a similar proceeding in De Azara, which induces me to give more credit to it.

He tells us, that in low districts in South America, that are exposed to inundations, conical hills of earth may be observed, about three feet high, and very near to each other, which are inhabited by a little black ant. When an inundation takes place, they are heaped together out of the nest into a circular mass, about a foot in diameter and four fingers in depth. Thus they remain floating upon the water while the inundation continues. One of the sides of the mass which they form is attached to some sprig of grass, or piece of wood; and when the waters are retired, they return to their habitation. When they wish to pass from one plant to another, they may often be seen formed into a bridge, of two palms length, and of the breadth of a finger, which has no other sup-

[a] *Insect. Surinam*, p. 18. In her plate the ants are represented so connected.

port than that of its two extremities. One would suppose that their own weight would sink them; but it is certain that the masses remain floating during the inundation, which lasts some days[a].

You must now be fully satiated with this account of the constant fatigue and labour to which our little pismires are doomed by the law of their nature; I shall therefore endeavour to relieve your mind by introducing you to a more quiet scene, and exhibit them to you during their intervals of repose and relaxation.

Gould tells us that the hill-ant is very fond of basking in the sun, and that on a fine serene morning you may see them conglomerated like bees on the surface of their nest, from whence, on the least disturbance, they will disappear in an instant[b]. M. Huber also observes, after their labours are finished, that they stretch themselves in the sun, where they lie heaped one upon another, and seem to enjoy a short interval of repose: and in the interior of an artificial nest, in which he had confined some of this species, where he saw many employed in various ways, he noticed some reposing which appeared to be asleep[c].

But they have not only their time for repose; they also devote some to relaxation, during which they amuse themselves with sports and games. "You may frequently perceive one of these ants (*F. rufa*) (says our Gould) run to and fro with a fellow-labourer in his forceps, of the same species and colony. It appeared first in the light of provisions; but I was soon undeceived by observing,

[a] *Voyages dans l'Amérique Mérid.* i. 187.
[b] Gould, 69. [c] Huber, 73.

that after being carried for some time, it was let go in a friendly manner, and received no personal injury. This amusement, or whatever title you please to give it, is often repeated, particularly amongst the hill-ants, who are very fond of this sportive exercise[a]." A nest of ants which Bonnet found in the head of a teazle, when enjoying the full sun, which seems the acme of formic felicity, amused themselves with carrying each other on their backs, the rider holding with his mandibles the neck of his horse, and embracing it closely with his legs[b]. But the most circumstantial account of their sports is given by Huber. "I approached one day," says he, "one of their formicaries (he is speaking of *F. rufa*) exposed to the sun and sheltered from the north. The ants were heaped together in great numbers, and seemed to enjoy the temperature which they experienced at the surface of the nest. None of them were working: this multitude of accumulated insects exhibited the appearance of a boiling fluid, upon which at first the eye could scarce fix itself without difficulty. But when I set myself to follow each ant separately, I saw them approach each other, moving their antennæ with astonishing rapidity; with their fore-feet they patted lightly the cheeks of other ants: after these first gestures, which resembled caresses, they reared upon their hind-legs by pairs, they wrestled together, they seized one another by a mandible, by a leg or an antenna, they then let go their hold to renew the attack; they fixed themselves to each other's trunk or abdomen, they embraced, they

[a] Gould, 103— [b] Bonnet, ii. 407.

turned each other over, or lifted each other up by turns ——they soon quitted the ants they had seized, and endeavoured to catch others: I have seen some who engaged in these exercises with such eagerness, as to pursue successively several workers; and the combat did not terminate till the least animated, having thrown his antagonist, accomplished his escape by concealing himself in some gallery [a]." He compares these sports to the gambols of two puppies, and tells us that he not only often observed them in this nest, but also in his artificial one.

I shall here copy for you a memorandum I made last year. "On the ninth of May, at half-past two, as I was walking on the Plumstead road near Norwich, on a sunny bank I observed a large number of ants (*Formica fusca*, L.) agglomerated in crowds near the entrances of their nest. They seemed to make no long excursions, as if intent upon enjoying the sun-shine at home; but all the while they were coursing about, and appeared to accost each other with their antennæ. Examining them very attentively, I at length saw one dragging another, which it absolutely lifted up by its antennæ, and carrying it in the air. I followed it with my eye, till it concealed itself and its antagonist in the nest. I soon noticed another that had recourse to the same manœuvres; but in this instance the ant that was attacked resisted manfully, a third sometimes appearing inclined to interfere: the result was, that this also was dragged in. A third was haled in by its legs, and a fourth by its man-

[a] Huber, 170—

dibles. What was the precise object of these proceedings, whether sport or violence, I could not ascertain. I walked the same way on the following morning, but at an earlier hour, when only a few comers and goers were to be seen near the nest:" And soon leaving the place, I had no further opportunity to attend to them.

And now having conducted you through every apartment of the formicary, and shown you its inhabitants in every light, I shall leave you to meditate on the extraordinary instincts with which their Creator has gifted them, reserving what I have to say on the other social insects for a future occasion.

I am, &c.

LETTER XVIII.

SOCIETIES OF INSECTS.

PERFECT SOCIETIES CONTINUED. (*Wasps and Humble-Bees.*)

I SHALL now call your attention to such parts of the history of two other descriptions of social insects, *wasps*, namely, and *humble-bees*, as have not been related to you in my letters on the affection of insects for their young, and on their habitations. What I have to communicate, though not devoid of interest, is not to be compared with the preceding account of the ants, nor with that which will follow of the hive-bee. This, however, may arise more from the deficiency of observations than the barrenness of the subject.

The first of these animals, *wasps*,—with whose proceedings I shall begin,—we are apt to regard in a very unfavourable light. They are the most impertinent of intruders. If a door or window be open at the season of the year in which they appear, they are sure to enter. When they visit us, they stand upon no ceremony, but make free with every thing that they can come at. Sugar, meat, fruit, wine, are equally to their taste; and if we attempt to drive them away, and are not very cautious, they will often make us sensible that they are not to be

provoked with impunity. Compared with the bees, they may be considered as a horde of thieves and brigands; and the latter as peaceful, honest, and industrious subjects, whose persons are attacked and property plundered by them. Yet, with all this love of pillage and other bad propensities, they are not altogether disagreeable or unamiable; they are brisk and lively; they do not usually attack unprovoked; and their object in plundering us is not purely selfish, but is principally to provide for the support of the young brood of their colonies.

The societies of wasps, like those of ants and other social *Hymenoptera*, consist of females, males, and workers. The *females* may be considered as of two sorts: first, the females by way of eminence, much larger than any other individuals of the community, equalling six of the workers (from which in other respects they do not materially differ) in weight, and laying both male and female eggs. Then the small females, not bigger than the workers, and laying only male eggs. This last description of females, which are found also both amongst the humble-bees and hive-bees, were first observed amongst the wasps by M. Perrot, a friend of Huber's[a]. The large females are produced later than the workers, and make their appearance in the following spring; and whoever destroys one of them at that time, destroys an entire colony, of which she would be the founder. They are more worthy of praise than the queen-bee; since upon the latter, from her very first appearance in the perfect state, no labour devolves,—all her wants being

[a] Huber, *Nouv. Observ.* ii. 443.

prevented by a host of workers, some of which are constantly attending upon her, feeding her, and permitting her to suffer no fatigue; while others take every step that is necessary for the safety and subsistence of the colony. Not so our female wasp;—she is at first an insulated being that has had the fortune to survive the rigours of winter. When in the spring she lays the foundation of her future empire, she has not a single worker at her disposal: with her own hands and teeth she often hollows out a cave wherein she may lay the first foundations of her paper metropolis; she must herself build the first houses, and produce from her own womb their first inhabitants; which in their infant state she must feed and educate, before they can assist her in her great design. At length she receives the reward of her perseverance and labour; and from being a solitary unconnected individual, in the autumn is enabled to rival the queen of the hive in the number of her children and subjects; and in the edifices which they inhabit—the number of cells in a vespiary sometimes amounting to more than 16,000, almost all of which contain either an egg, a grub, or a pupa; and each cell serving for three generations in a year; which, after making every allowance for failures and other casualties, will give a population of at least 30,000. Even at this time, when she has so numerous an army of coadjutors, the industry of this creature does not cease, but she continues to set an example of diligence to the rest of the community.—If by any accident, before the other females are hatched, the queen mother perishes, the neuters cease their labours, lose their instincts, and die.

The number of females in a populous vespiary is con-

siderable, amounting to several hundred; they emerge from the pupa about the latter end of August, at the same time with the males, and fly in September and October, when they pair. Of this large number of females, very few survive the winter. Those that are so fortunate remain torpid till the vernal sun recalls them to life and action. They then fly forth, collect provision for their young brood, and are engaged in the other labours necessary for laying the foundation of their empire: but in the summer months they are never seen out of the nest.

The *male* wasps are much smaller than the female, but they weigh as much as two workers. Their antennæ are longer than those of either, not, like theirs, thicker at the end, but perfectly filiform; and their abdomen is distinguished by an additional segment. Their numbers about equal those of the females, and they are produced at the same time. They are not so wholly given to pleasure and idleness as the drones of the hive. They do not, indeed, assist in building the nest, and in the care of the young brood; but they are the scavengers of the community; for they sweep the passages and streets, and carry off all the filth. They also remove the bodies of the dead, which are sometimes heavy burthens for them; in which case two unite their strength to accomplish the work; or, if a partner be not at hand, the wasp thus employed cuts off the head of the defunct, and so effects its purpose. As they make themselves so useful, they are not, like the male bees, devoted by the workers to an universal massacre when the impregnation of the females, the great end of their creation, is answered; but they share the general lot of the community, and are suffered

to survive till the cold cuts off them and the workers together.

The *workers* are the most numerous, and to us the only troublesome part of the community; upon whom devolves the main business of the nest. In the summer and autumnal months, they go forth by myriads into the neighbouring country to collect provisions; and on their return to the common den, after reserving a sufficiency for the nutriment of the young brood, they divide the spoil with great impartiality;—part being given to the females, part to the males, and part to those workers that have been engaged in extending and fortifying the vespiary. This division is voluntarily made, without the slightest symptom of compulsion. Several wasps assemble round each of the returning workers, and receive their respective portions. It is curious and interesting to observe their motions upon this occasion. As soon as a wasp, that has been filling itself with the juice of fruits, arrives at the nest, it perches upon the top, and disgorging a drop of its saccharine fluid, is attended sometimes by two at once, who share the treasure: this being thus distributed, a second and sometimes a third drop is produced, which falls to the lot of others.

Another principal employment of the workers is the enlarging and repairing of the nest. It is extremely amusing to see them engaged upon this foliaceous covering. They work with great celerity; and though a large number are occupied at the same time, there is not the least confusion. Each individual has its portion of work assigned to it, extending from an inch to an inch and a half, and is furnished with a ball of ligneous fibre, scraped or

rather plucked by its powerful jaws from posts, rails, and the like. This is carried in its mouth, and is thus ready for immediate use:—but upon this subject I have enlarged in a former letter [a]. The workers also clean the cells and prepare them to receive another egg, after the imago is disclosed and has left it.

There is good reason for thinking, and the opinion has the sanction of Sir Joseph Banks, that wasps have sentinels placed at the entrances of their nests, which if you can once seize and destroy, the remainder will not attack you. This is confirmed by an observation of Mr. Knight's in the *Philosophical Transactions* [b], that if a nest of wasps be approached without alarming the inhabitants, and all communication be suddenly cut off between those out of the nest and those within it, no provocation will induce the former to defend it and themselves. But if one escapes from within, it comes with a very different temper, and appears commissioned to avenge public wrongs, and prepared to sacrifice its life in the execution of its orders. He discovered this when quite a boy.

It sometimes happens, that when a large number of female wasps have been observed in the spring, and an abundance of workers has in consequence been expected to make their attack upon us in the summer and autumn, but few have appeared. Mr. Knight observed this in 1806, and supposes it to be caused by a failure of males [c]. I have since more than once made the same observation, and Major Moor, as well as myself, noticed it last year (1815). What took place here in the present year (1816) may in some degree account for it. Though the summer has

[a] Vol. I. 4th Ed. p. 507. [b] For 1807, 242— [c] Ibid. 243.

been so wet, and one may almost say winterly, there were in the neighbourhood in which I reside abundance of wasps at the usual time; but, except on some few warm days, in which they were very active, benumbed by the cold they were crawling about upon the floors of my house and seemed unable to fly. In this vicinity numbers make their nests in the banks of the river. In the beginning of the month of October there was a very considerable inundation, after which not a single wasp was to be seen. The continued wet that produces an inundation may also destroy those nests that are out of the reach of the waters;—and perhaps this cause may have operated in those years above alluded to, in which the appearance of the workers in the summer and autumn did not correspond with the large numbers of females observed in the spring.

In ordinary seasons, in the month lately mentioned, October, wasps seem to become less savage and sanguinary; for even flies, of which earlier in the summer they are the pitiless destroyers, may be seen to enter their nests with impunity. It is then, probably, that they begin to be first affected by the approach of the cold season, when nature teaches them it is useless longer to attend to their young. They themselves all perish, except a few of the females, upon the first attack of frost.

Reaumur, from whom (see the sixth Memoir of his last volume) most of these observations are taken, put the nests of wasps under glass hives, and succeeded so effectually in reconciling these little restless creatures to them, that they carried on their various works under his eye: and if you feel disposed to follow his example, I have no doubt you will throw light upon many parts

of their history, concerning which we are now in darkness.

Having given you some idea, imperfect indeed from the want of materials, of the societies of wasps, I must next draw up for you the best account I can of those of the *humble-bees.* These form a kind of intermediate link between the wasps and the hive-bees, collecting honey indeed and making wax, but constructing their combs and cells without the geometric precision of the latter, and of a more rude and rustic kind of architecture; and distinguished from both, though they approach nearer to the bees, by the extreme hairiness of their bodies.

The population of a humble-bees nest may be divided into four orders of individuals: the large females; the small females; the males; and the workers.

The large *females,* like the female wasps, are the original founders of their republics. They are often so large, that by the side of the small ones or the workers, which in every other respect they exactly resemble, they look like giants opposed to pygmies. They are excluded from the pupa in the autumn; and pair in that season, with males produced from the eggs of the small females. They pass the winter under ground, and, as appears from an observation of M. P. Huber, in a particular apartment, separate from the nest, and rendered warm by a carpeting of moss and grass, but without any supply of food. Early in the spring, (for they make their first appearance as soon as the catkins of the sallows and willows are in flower,) like the female wasps, they lay the foundations of a new colony without the assistance of any neuters, which all perish before the winter. In some in-

stances however, if a conjecture of M. de la Billardière be correct, these creatures have an assistant assigned to them. He says, at this season (the approach of winter) he found in the nest of *Apis Sylvarum* (Kirby) some old females and workers, whose wings were fastened together to retain them in the nest by hindering them from flying; these wings in each individual were fastened together at the extremity, by means of some very brown wax applied above and below[a]. This he conceives to be a precaution taken by the other bees to oblige these individuals to remain in the nest and take care of the brood that was next year to renew the population of the colony. I feel, however, great hesitation in admitting this conjecture, founded upon an insulated and perhaps an accidental fact. For, in the first place, the young females that come forth in the autumn, and not the old ones, are the founders of new colonies; and their instinct directs them to fulfill the great laws of their nature without such compulsion; and in the next, the workers are never known to survive the cold of winter.

The employment of a large female, besides the care of the young brood before described, and the collecting of honey and pollen, is principally the construction of the cells in which her eggs are to be laid; which M. P. Huber seems to think, though they often assist in it, the workers are not able to complete by themselves. So rapid is the female in this work, that to make a cell, fill it with pollen, commit one or two eggs to it, and cover them in, requires only the short space of half an hour.

[a] *Mémoires du Muséum*, &c. i. 55.

Her family at first consists only of workers, which are necessary to assist her in her labours; these appear in May and June: but the males and females are later, and sometimes are not produced before August and September[a]. As in the case of the hive-bee, the food of these several individuals differs; for the grubs that will turn to workers are fed with honey and pollen mixed, while those that are destined to be males and females are supplied with pure honey.

The instinct of these larger females does not develop itself all at once: for it is a remarkable fact, that when they are first hatched in the autumn, not being in a condition to become mothers, they are no object of jealousy to the small queens, (as we shall soon see they are when engaged in oviposition,) and are employed in the ordinary labours of the parent nest—that is, they collect honey and pollen, and make wax; but they do not construct cells. The building instinct seems as it were in suspense, and does not manifest itself till the spring; when the maternal sentiment impels them at the same time to lay eggs and to construct the cells in which they are to be deposited.

I have told you above, that amongst the wasps a *small* kind of *female* has been discovered: this is the case also amongst the humble-bees, in whose societies they are more readily detected: not indeed by any observable

[a] P. Huber, in *Linn. Trans.* vi. 264.—This author says however, in another place (*ibid.* 285), that the male eggs are laid in the spring, at the same time with those that are to produce workers. Perhaps by the former he means the male offspring of the small females, and by the latter those of the large?

difference between them and the workers, but chiefly by the difference of their instincts:—from the other females they are distinguished solely by their diminutive size. Like those of the wasps and hive-bees, these minor queens produce only male eggs, which come out in time to fertilize the young females that found the vernal colonies. M. P. Huber suspects that, as in the case of the female bee, it is a different kind of food that develops their ovaries, and so distinguishes them from the workers. They are generally attended by a small number of males, who form their court.

M. Huber, watching at midnight the proceedings of a nest which he kept under a glass, observed the inhabitants to be in a state of great agitation: many of these bees were engaged in making a cell; the queen-mother of the colony, as she may be called, who is always extremely jealous of her pygmy rivals, came and drove them away from the cell;—she in her turn was driven away by the others, which pursued her, beating their wings with the utmost fury, to the bottom of the nest. The cell was then constructed, and two of them at the same time oviposited in it. The queen returned to the charge, exhibiting similar signs of anger; and, chasing them away again, put her head into the cell, when seizing the eggs that had been laid, she was observed to eat them with great avidity. The same scene was again renewed, with the same issue. After this, one of the small females returned and covered the empty cells with wax. When the mother-queen was removed, several of the small females contended for the cell with indescribable rage, all endeavouring to lay their eggs in

it at the same time. These small females perish in the autumn.

The *males* are usually smaller than the large females, and larger than the small ones and workers. They may be known by their longer, more filiform, and slenderer antennæ; by the different shape and by the beard of their mandibles. Their posterior tibiæ also want the *corbicula* and *pecten* that distinguish the individuals of the other sex, and their posterior plantæ have no auricle. We learn from Reaumur that the male humble-bees are not an idle race, but work in concert with the rest to repair any damage or derangement that may befall the common habitation.

The *workers*, which are the first fruits of the queen-mother's vernal parturition, assist her, as soon as they are excluded from the pupa, in her various labours. To them also is committed the construction of the waxen vault that covers and defends the nest. When any individual larva has spun its cocoon and assumed the pupa, the workers remove all the wax from it; and as soon as it has attained to its perfect state, which takes place in about five days, the cocoons are used to hold honey or pollen. When the bees discharge the honey into them upon their return from their excursions, they open their mouths and contract their bodies, which occasions the honey to fall into the reservoir. Sixty of these honey-pots are occasionally found in a single nest, and more than forty are sometimes filled in a day. In collecting honey, humble-bees, if they cannot get at that contained in any flower by its natural opening, will often make an aperture at the base of the corolla, or even in the calyx,

that they may insert their proboscis in the very place where nature has stored up her nectar[a]. M. Huber relates a singular anecdote of some hive-bees paying a visit to a nest of humble-bees placed under a box not far from their hive, in order to steal or beg their honey; which places in a strong light the good temper of the latter. This happened in a time of scarcity. The hive-bees, after pillaging, had taken almost entire possession of the nest. Some humble-bees which remained in spite of this disaster, went out to collect provisions; and bringing home the surplus after they had supplied their own immediate wants, the hive-bees followed them, and did not quit them till they had obtained the fruit of their labours. They licked them, presented to them their proboscis, surrounded them, and thus at last persuaded them to part with the contents of their honey-bags. The humble-bees after this flew away to collect a fresh supply. The hive-bees did them no harm, and never once showed their stings;—so that it seems to have been persuasion rather than force that produced this singular instance of self-denial. This remarkable manœuvre was practised for more than three weeks; when the wasps being attracted by the same cause, the humble-bees entirely forsook the nest[b].

The workers are the most numerous part of the community, but are nothing when compared with the numbers to be found in a vespiary or a beehive:—two or three hundred is a large population for a humble-bees

[a] Hub. *Nouv. Observ.* ii. 375. [b] Ibid. 373—

nest; in some species it not being more than fifty or sixty.—They may more easily be studied than either wasps or hive-bees, as they seem not to be disturbed or interrupted in their works by the eye of an observer[a].

I am, &c.

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[a] This account of the proceedings of humble-bees is chiefly taken from Reaumur, vi. *Mem.* 1.; and M. P. Huber in *Linn. Trans.* vi. 214—

LETTER XIX.

SOCIETIES OF INSECTS.

PERFECT SOCIETIES CONTINUED. (*The Hive-bee.*)

THE glory of an all-wise and omnipotent Creator, you will acknowledge, is wonderfully manifested by the varied proceedings of those social tribes of which I have lately treated: but it shines forth with a brightness still more intense in the instincts that actuate the *hive-bee*, and which I am next to lay before you. Indeed, of all the insect associations, there are none that have more excited the attention and admiration of mankind in every age, or been more universally interesting, than the colonies of these little useful creatures. Both Greek and Roman writers are loud in their praise; nay, some philosophers were so enamoured of them, that, as I observed before[a], they devoted a large portion of their time to the study of their history. Whether the knowledge they acquired was at all equivalent to the years that were spent in the attainment of it, may be doubted: for, were it so, it is probable that Aristotle and Pliny would have given a clearer and more consistent account of the in-

[a] Vol. I. 4th Ed. 485.

habitants of the hive than they have done. Indeed, had their discoveries borne any proportion to the long tract of time asserted to have been employed by some in the study of these insects, they ought to have rivalled, and even exceeded, those of the Reaumurs and Hubers of our own age.

Numerous, and wonderful for their absurdity, were the errors and fables which many of the ancients adopted and circulated with respect to the generation and propagation of these busy insects. For instance,—that they were sometimes produced from the putrid bodies of oxen and lions; the kings and leaders from the brain, and the vulgar herd from the flesh—a fable derived probably from swarms of bees having been observed, as in the case of Samson[a], to take possession of the dried carcases of these animals, or perhaps from the myriads of flies (for the vulgar do not readily distinguish flies from bees) often generated in their putrescent flesh. They adopted another notion equally absurd; that these insects collect their young progeny from the blossoms and foliage of certain plants. Amongst others, the Cerinthus, the reed, and the olive-tree, had this virtue of generating infant bees attributed to them[b]. These specimens of ancient credulity will suffice.

But do not think that all the ancients imbibed such monstrous opinions. Aristotle's sentiments seem to have been much more correct, and not very wide of what some of our best modern apiarists have advanced. According to him, the kings (so he denominates the queen-bee) generate both kings and workers; and the latter

[a] Judges xiv. 8, 9. [b] See Aristot. *Hist. Animal.* l. v. c. 22. Virgil. *Georgic.* l. iv.; and Mouffet, 12—.

the drones. This he seems to have learned from keepers of bees. The kings, says he in another place, are the parents of the bees, and the drones their children. It is right, he observes again, that the kings (which by some were called mothers) should remain within the hive unfettered by any employment, because they are made for the multiplication of the species[a]. To the same purpose Riem of Lauten of the *Palatinate Apiarian Society*, and Wilhelmi of the *Lusatian*, affirm that the queen lays the eggs which produce the queens and workers; and the workers those that produce the drones or males[b]. Aristotle also tells us, that some in his time affirmed that the bees (the workers) were the females, and the drones the males: an opinion which he combats from an analogy pushed rather too far, that nature would never give offensive armour to females[c]. In another place he appears to think that the workers are hermaphrodites: —his words are remarkable, and seem to indicate that he was aware of the sexes of plants: "having in themselves," says he, "*like plants*, the male and the female[d]."

Fables and absurdities, however, are not confined to the ancients, nor even to those moderns who lived before Swammerdam, Maraldi, Reaumur, Bonnet, Schirach, John Hunter, Huber, and their followers, by their observations and discoveries had thrown so much light upon this interesting subject. Even in our own times, a Neapolitan professor, Monticelli, asserts, on the authority of a certain father Tanoya, that in every hive there

[a] Aristot. *ubi supr.* c. 21. *De Generat. Animal.* l. iii. c. 10, where there is some curious reasoning upon this subject.

[b] Bonnet, x. 199—. 236—.

[c] *Hist. Animal.* l. v. c. 22. [d] *De Generat. Animal.* l. iii. c. 10.

are three sorts of bees independent of each other; viz. male and female drones—male and female, I must not say *queens*—call them what you will; and male and female workers; and that each construct their own cells!!! Another writer, Mr. Huish, whose work has just made its appearance, and whose presumption can only be equalled by his ignorance[a], denies most of the modern discoveries, and asserts that the queen always remains a virgin!! Enough, however, upon this subject. I shall now endeavour to lay before you the best authenticated facts in the history of these animals; but you must not expect an account of them complete in all its parts; for, much as we know, Bonnet's observation will still hold good: "The more I am engaged in making fresh observations upon bees, the more steadfast is my conviction, that the time is not yet arrived in which we can draw satisfactory conclusions with respect to their policy. It is only by varying and combining experiments in a thousand ways, and by placing these industrious flies in circumstances more or less removed from their ordinary state, that we can hope to ascertain the right direction of their instinct, and the true principles of their government[b].

What I have further to say concerning these admirable creatures, will be principally taken from the two authors who have given the clearest and most satisfactory account of them, Reaumur and the elder Huber;

[a] The following passage, in which he speaks of the *Sphinx Atropos* as belonging to Linné's *three* lepidopterous genera, will sufficiently justify this assertion. The Death-headed *Sphinx* (*Sphinx Atropos*) is a great *butterfly*, and belongs also to the genus *Phalenæ*, p. 126!!!

[b] *Œuvr.* x. 194—

though I shall add from other sources such additional observations as may serve better to elucidate their history.

The society of a hive of bees, besides the young brood, consists of one female or queen; several hundreds of males or drones; and many thousand workers.

The *female*, or queen, first demands our attention. Two sorts of females have been observed amongst the bees, a large one and a small. Mr. Needham was the first that observed the latter; and their existence, M. P. Huber tells us, has been confirmed by several observations of his father. They are bred in cells as large as those of the common queens, from which they differ only in size. Though they have ovaries, they have never been observed to lay eggs[a]. Having never seen one of these, for they are of very rare occurrence, my description must be confined to the common female, the genuine monarch of the hive[b].

[a] Bonnet, x. P. Huber in *Linn. Trans.* vi. 283. Reaumur (v. 373) observes that some queens are much larger than others; but he attributes this difference of their size to the state of the eggs in their body.

[b] As every reader is not aware of the differences of form, &c. that distinguish the females, males, and workers from each other (I have seen the male mistaken for a distinct species, and placed in a cabinet as *Apis lagopoda*, L.), I shall here subjoin a description of each.—i. The *body* of the *Female* bee is considerably longer than that of either the drone or the worker. The prevailing colour in all three is the same, black or black-brown; but with respect to the female this does not appear to be invariably the case; for—not to insist upon Virgil's royal bees glittering with ruddy or golden spots and scales, where allowance must be made for poetic license—Reaumur affirms, after describing some differences of colour in different individuals of this sex, that a queen may always be distinguished, both from the workers and males, by the colour of her body *. If this observation be restricted to the colour of some parts of her body, it is correct;

* Reaumur, v. 375.

There are two descriptions of males—one not bigger than the workers, supposed to be produced from a male

but it will not apply to all generally (unless, as I suspect may be the case, by the term body he means the abdomen), for, in all that I have had an opportunity of examining, the prevailing colour, as I have stated it, is the same.

The *head* is not larger than that of the workers; but the *tongue* is shorter and more slender, with straighter *maxillæ*. The *mandibles* are forficate, and do not jut out like theirs into a prominent angle; they are of the colour of pitch with a red tinge, and terminate in two teeth, the exterior being acute, and the interior blunt or truncated. The *labrum* or upper-lip is fulvous; and the *antennæ* are piceous.

In the *trunk*, the *tegulæ* or scales that defend the base of the wings are rufo-piceous. The *wings* reach only to the tip of the third abdominal segment. The *tarsi* and the apex of the *tibiæ* are rufo-fulvous. The posterior *tibiæ* are plane above and covered with short adpressed hairs, having neither the *corbicula* (or marginal fringe of hairs for carrying the masses of pollen) nor the *pecten*; and the posterior *plantæ* have neither the brush formed of hairs set in striæ, nor the auricle at the base.

The *abdomen* is considerably longer than the head and trunk taken together, receding from the trunk, elongato-conical, and rather sharp at the anus. The *dorsal* segments are fulvous at the tip; covered with very short, pallid, and, in certain lights, shining adpressed hairs; the first segment being very short, and covered with longer hairs. The *ventral* segments, except the *anal*, which is black, are fulvescent or rufo-fulvous, and covered with soft longer hairs. The *vagina* of the *spicula* (commonly called the sting) is curved.

ii. The *Male* bee, or drone, is quite the reverse of his royal paramour; his body being thick, short, and clumsy, and very obtuse at each extremity *. It is covered also, as to the *head* and *trunk*, with dense hairs.

The *head* is depressed and orbicular. The *tongue* is shorter and more slender than that of the female; and the *mandibles*, though

* Virgil seems to have regarded the drone as one of the sorts of kings or leaders of the bees, when he says, speaking of the latter,

" . . . . Ille horridus alter
Desidiâ, latamque trahens inglorius alvum."

Georgic. iv. l. 93.

egg laid in a worker's cell. The common males are much larger, and will counterpoise two workers.

I have before observed to you that there are two sorts

nearly of the same shape, are smaller. The *eyes* are very large, meeting at the back part of the head. In the space between them are placed the *antennæ* and *stemmata.* The former consist of fourteen joints, including the *radicle*, the fourth and fifth being very short and not easily distinguished.

The *trunk* is large. The *wings* are longer than the body. The *legs* are short and slender. The *posterior tibiæ* are long, club-shaped, and covered with inconspicuous hairs. The *posterior plantæ* are furnished underneath with thick-set *scopulæ*, which they use to brush their bodies.

The *claw-joints* are fulvescent.

The *abdomen* is cordate, very short, being scarcely so long as the head and trunk together, consisting of seven segments, which are fulvous at their apex. The first segment is longer than any of the succeeding ones, and covered above with rather long hairs. The second and third dorsal segments are apparently naked; but under a triple lens, in a certain light, some adpressed hairs may be perceived;—the remaining ones are hairy, the three last being inflexed. The ventral segments are very narrow, hairy, and fulvous.

iii. The *body* of the *Workers* is oblong.

The *head* triangular. The *mandibles* are prominent, so as to terminate the head in an angle, toothless and forcipate. The *tongue* and *maxillæ* are long and incurved: the *labrum* and *antennæ* black.

In the *trunk* the *tegulæ* are black. The *wings* extend only to the apex of the fourth segment of the abdomen. The *legs* are all black, with the *digits* only rather piceous. The posterior *tibiæ* are naked above, exteriorly longitudinally concave, and interiorly longitudinally convex; furnished with lateral and recumbent hairs to form the *corbicula*, and armed at the end with the *pecten.* The upper surface of the *posterior plantæ* resembles that of the *tibiæ*; underneath they are furnished with a *scopula* or brush of stiff hairs set in rows: at the base they are armed with stiff bristles, and exteriorly with an acute appendage or *auricle.*

The *abdomen* is a little longer than the head and trunk together; oblong, and rather heart-shaped—a transverse section of it is triangular. It is covered with longish flavo-pallid hairs: the first segment is short with longer hairs; the base of the three intermediate seg-

of workers, the wax-makers and nurses[a]. They may also be further divided into fertile and sterile[b]: for some of them, which in their infancy are supposed to have partaken of some portion of the royal jelly, lay male eggs. There is found in some hives, according to Huber, a kind of bees, which from having less down upon the head and thorax appear blacker than the others, by whom they are always expelled from the hive, and often killed. Perfect ovaries, upon dissection, were discovered in these bees, though not furnished with eggs. This discovery induced M[lle] Jurine, the lady who dissected them, to examine the common workers in the same way; and she found in all that she examined, what had escaped Swammerdam, perfect though sterile ovaries[c]. It is worth inquiry, though Mr. Huber gives no hint of this kind, whether these were not in fact superannuated bees, that could no longer take part in the labours of the hive. Thorley remarks, which confirms this idea, that, if you closely observe a hive of bees in July, you may perceive many amongst them of a dark colour, with wings rent and torn; but that in September not one of them is to be seen[d]. Huber does not say whether the wings of the bees in question were lacerated; but in superan-

ments is covered, and as it were banded, with pale hairs. The apex of the three intermediate ventral segments is rather fulvescent, and their base is distinguished on each side by a trapeziform *wax-pocket* covered by a thin membrane. The sting, or rather *vagina* of the *spicula*, is straight.

[a] See Vol. I. 4th Ed. p. 490.

[b] In hives where a queen laying male eggs has been killed, the workers continue to make only male cells, though supplied with a fertile queen, and the fertile workers lay eggs in them. *Schirach*, 258.

[c] Huber, ii. 425—

[d] Thorley, *On Bees*, 179.

nuated insects the hair is often rubbed off the body, which gives them a darker hue than that of more recent individuals of the same species. Should this conjecture turn out true, their banishment and destruction of the seniors of the hive would certainly not show our little creatures in a very amiable point of view. Yet it seems the law of their nature to rid their community of all supernumerary and useless members, as is evident from their destruction of the drones after their work is done.

It is not often that insects have been weighed; but Reaumur's curiosity was excited to know the weight of bees; and he found that 336 weighed an ounce, and 5376 a pound. According to John Hunter, an ale-house pint contains 2160 workers.

I have described to you the persons of the different individuals that compose the society of the bee-hive more in detail than I should otherwise have done, in order that you may be the better able to form a judgement upon a most extraordinary circumstance in their history, which is supported by evidence that seems almost incontrovertible. The fact to which I allude is this—that if the bees are deprived of their queen, and are supplied with comb containing young worker brood only, they will select one or more to be educated as queens; which, by having a royal cell erected for their habitation, and being fed with royal jelly for not more than two days, when they emerge from the pupa state (though, if they had remained in the cells which they originally inhabited, they would have turned out workers) will come forth complete queens, with their form, instincts, and powers of generation entirely different. In order to produce this effect, the grub must not be more than three days old; and this is the age

at which, according to Schirach, (the first apiarist who called the public attention to this miracle of nature,) the bees usually elect the larvæ to be royally educated; though it appears from Huber's observations, that a larva two days or even twenty-four hours old will do[a].—Having chosen a grub, they remove the inhabitants and their food from two of the cells which join that in which it resides; they next take down the partitions which separate these three cells; and, leaving the bottoms untouched, raise round the selected worm a cylindrical tube, which follows the horizontal direction of the other cells: but since at the close of the third day of its life its habitation must assume a different form and direction, they gnaw away the cells below it, and sacrifice without pity the grubs they contain, using the wax of which they were formed to construct a new pyramidal tube, which they join at right angles to the horizontal one, the diameter of the former diminishing insensibly from its base to its mouth. During the two days which the grub inhabits this cell, like the common royal cells now become vertical[b], a bee may always be observed with its head plunged into it; and when one quits it another takes its place. These bees keep lengthening the cell as the worm grows older, and duly supply it with food, which they place before its mouth, and round its body. The animal, which can only move in a spiral direction, keeps incessantly turning to take the jelly deposited before it; and thus slowly working downwards, arrives insensibly near the orifice of the cell, just at the time that it is ready to assume the pupa;

[a] Huber, i. 137.

[b] Reaumur, who was however unacquainted with this extraordinary fact, has figured one of these cells, v. *t.* 32. *f.* 3. *h.*

when, as before described, the workers shut up its cradle with an appopriate covering[a].

When you have read this account, I fear, with the celebrated John Hunter, you will not be very ready to believe it, at least you will call upon me to bring forth my "strong reasons" in support of it. What!—you will exclaim—can a larger and warmer house (for the royal cells are affirmed to enjoy a higher temperature than those of the other bees[b]), a different and more pungent kind of food, and a vertical instead of a horizontal posture, in the first place, give a bee a differently shaped tongue and mandibles; render the surface of its posterior tibiæ flat instead of concave; deprive them of the fringe of hairs that forms the basket for carrying the masses of pollen; of the auricle and pecten which enable the workers to use these tibiæ as pincers[c]; of the brush that lines the inside of their plantæ? Can they lengthen its abdomen; alter its colour and clothing; give a curve to its sting; deprive it of its wax-pockets, and of the vessels for secreting that substance; and render its ovaries more conspicuous, and capable of yielding female as well as male eggs? Can, in the next place, the seemingly trivial circumstances just enumerated altogether alter the instinct of these creatures? Can they give to one description of animals address and industry; and to the other astonishing fecundity? Can we conceive them to change the very passions, tempers, and manners? That the very same fœtus, if fed with more pungent food, in a higher temperature and in a vertical position, shall become a female destined to enjoy love, to burn with jealousy and anger, to be in-

[a] Compare Bonnet, x. 156, with Huber, i. 134— [b] Schirach, 69.
[c] Huber, t. 4. f. 4—6.

cited to vengeance, and to pass her time without labour—that this very same fœtus, if fed with more simple food, in a lower temperature, in a more confined and horizontal habitation, shall come forth a worker zealous for the good of the community, a defender of the public rights, enjoying an immunity from the stimulus of sexual appetite and the pains of parturition—laborious, industrious, patient, ingenious, skilful—incessantly engaged in the nurture of the young; in collecting honey and pollen; in elaborating wax; in constructing cells, and the like!—paying the most respectful and assiduous attention to objects which, had its ovaries been developed, it would have hated, and pursued with the most vindictive fury till it had destroyed them! Further, that these factitious queens (I mean those that the bees elect from amongst worker brood, and educate to supply the place of a lost one in the manner just described) shall differ remarkably from the natural queens, (or those that have been wholly educated in a royal cell,) in being altogether mute[a]—All this, you will think, at first sight, so improbable, and next to impossible, that you will require the strongest and most irrefragable evidence before you will believe it.

In spite of all these powerful probabilities to the contrary, this astonishing and seemingly incredible fact rests upon strong foundations, and is established by experiments made at different times, by different persons of the highest credit, in different parts of Europe. The first who brought it before the public (as I lately observed) was M. Schirach, secretaryof an Apiarian Society established at Little Bautzen in Upper Lusatia. He observed, that bees

[a] Huber, i.292.

when shut up with a portion of comb, containing only worker brood, would soon erect royal cells, and thus obtain queens:—the experiment was frequently repeated, and the result was almost uniformly the same. In one instance he tried it with a single cell, and it succeeded [a]. This curious fact was communicated to the celebrated Bonnet, who, though he hesitated long before he admitted it, was at length fully convinced. M. Wilhelmi (Schirach's brother-in-law), though at first he accounted for the fact upon other principles, and objected strongly to the doctrine in question, induced by the powerful evidence in favour of it, at last gave up his former opinion, and embraced it. And, to mention no more, the great Aristomachus of modern times, M. Huber, by experiments repeated for ten years, was fully convinced of the truth of Schirach's position [b].

The fact in question, though the public attention was first called to it by the latter gentleman, had indeed been practically known long before he wrote. M. Vogel, in a letter to Wilhelmi, asserts that numerous experiments confirming this extraordinary fact had been made by more than a hundred different persons, in the course of more than a hundred years; and that he himself had known old cultivators of bees who had unanimously declared to him, that, when proper precautions were taken, in a practice of more than fifty years, the experiment had never failed [c]. Signor Monticelli, the Neapolitan professor before mentioned, informs us that the Greeks and Turks of the Ionian Islands know how to make artificial swarms; and that the art of producing

[a] Bonnet, x. [b] Huber, i. 132. [c] Schirach, 121.

queens at will has been practised by the inhabitants of a little Sicilian island called Favignana, from very remote antiquity; and he even brings arguments to prove that it was no secret to the Greeks and Romans[a], though had the practice been common it would surely have been noticed by Aristotle and Pliny.

Bonner, a British apiarist, asserts that he has had successful recourse to the Lusatian experiment[b]; and Mr. Payne of Shipdam in Norfolk (who for many years has been engaged in the culture of bees, and has paid particular attention to their proceedings) relates that he well remembers that the bees of one of his hives, which he discovered had lost their queen, were engaged in erecting some royal cells upon the ruins of some of the common ones. He also informs me that he has found Huber's statements, as far as he has had an opportunity of verifying them, perfectly accurate.

As I think you will allow that the evidence just detailed to you is abundantly sufficient to establish the fact in question, we will now see whether any satisfactory account can be given for such changes being produced by such causes. "It does not appear to me improbable," says Bonnet, "that a certain kind of nutriment, and in more than usual abundance, may cause a development in the grubs of bees, of organs which would never be developed without it. I can readily conceive also, that a habitation considerably more spacious, and differently placed, is absolutely necessary to the complete development of organs which the new nutriment may cause to grow in all directions[c]." And again, with respect to the

[a] Huber, ii. 453. [b] Bonner *on Bees*, 56. [c] Huber, ii. 445.

wings of the queen bee, which do not exceed those of the workers in length, he thinks that this may arise from their being of a substance too stiff to admit of their extension. Those parts and points that were in a state to yield most easily to the action which this kind of nutriment produced, would be most prominent; and the vertical position of the grub and pupa, since nature does nothing in vain, may probably assist this action, and render the parts of the animal more capable of such extension than if it continued in a horizontal position.

We know, with respect to the human species and the larger animals, that numerous differences, both as to the form and relative proportion of parts, occur continually. The cause of these differences we cannot always ascertain; yet in many instances they may either be derived from the nutriment which the embryo receives in the womb, or from the greater or less dimensions or higher or lower temperature of that organ—a case that analogically would not be very wide of that of the grub or embryo of a bee inclosed in a cell. Some of the differences in man I now allude to, may often be caused by a particular diet in childhood; a warmer or a colder, a looser or a tighter dress, or the like. Thus, for instance, the Egyptians, who went bare-headed, had their skulls remarkably thick; while the Persians, who covered the head with a turban or mitre, were distinguished by the tenuity of theirs. Again, the inhabitants of certain districts are often remarkable for peculiarities of form, which are evidently produced by local circumstances.

The following reasoning may not be inapplicable to the development or non-development, according to their food and habitation, of the ovaries of these insects. An

infant tightly swathed, as was formerly the custom, in swaddling bands, without being allowed the free play of its little limbs, fed with unwholesome food, or uncherished by genial warmth, may from these circumstances have so imperfect a development of its organs as to be in consequence devoted to sterility. When a cow brings forth two calves, and one of them is a female, it is always barren, and partakes in part of the characters of the other sex[a]. In this instance, the space and food that in ordinary cases are appropriated to one, are divided between two; so that a more contracted dwelling and a smaller share of nutriment seem to prevent the development of the ovaries.

The following observations, mostly taken from an essay of the celebrated anatomist John Hunter, in the *Philosophical Transactions*, since they are intimately connected with the subject that we are now considering, will not be here misplaced. In animals just born, or very young, there are no peculiarities of shape, exclusive of the primary distinctions, by which one sex may be known from the other. Thus secondary distinctive characters, such as the beard in men, and the breasts in women, are produced at a certain period of life; and these secondary characters, in some instances, are changed for those of the other sex; which does not arise from any action at the first formation, but takes place when the great command "Increase and multiply" ceases to operate. Thus women in advanced life are sometimes distinguished by beards; and after they have done laying, hen-birds occasionally assume the plumage

[a] See J. Hunter's *Treatise on certain Parts of the Animal Œconomy.*

of the cock: this has been observed more than once by ornithologists, more particularly with respect to the pheasant and the pea-hen[a].—For females to assume the secondary characters of males, seems certainly a more violent change, than for a worker bee, which may be regarded as a sterile female, in consequence of a certain process, to assume the secondary characters of a fertile female.

With respect to the variations of instinct and character which result from the different modes of rearing the young bees that we are now considering; it would not, I think, be difficult to prove, that causes at first sight equally inadequate have produced effects full as important on the habits, tempers, and characters of men and other animals: but as these will readily occur to you, I shall not now enlarge upon them.

Did we know the causes of the various deviations, as to form and the like, observable in the three kingdoms of nature, and could apply them, we should be able to produce these deviations at our pleasure. This is exactly what the bees do. Their instinct teaches them that a certain kind of food, supplied to a grub inhabiting a certain dwelling, in a certain position, will produce certain effects upon it, rendering it different from what it would have been under ordinary circumstances, and fitted to answer their peculiar wants.

I trust that these arguments and probabilities will in some degree reconcile you to what at first sight seems so extraordinary and extravagant a doctrine. If not yet fully satisfied, I can only recommend your having re-

[a] *Philos. Trans.* 1792. viii. 167. Hunter *on certain Parts of the Animal Œconomy*, p. 65. Latham, *Synops.* ii. 672. t. 60.

course to experiments yourself. Leaving you therefore to this best mode of proof, I shall proceed to another part of my history:—but first I must mention an experiment of Reaumur's, which seems to come well in here. To ascertain whether the expectation of a queen was sufficient to keep alive the instinct and industry of the worker-bees, he placed in a glazed hive some royal cells containing both grubs and pupæ, and then introduced about 1000 or 1500 workers and some drones. These workers, which had been deprived of their queen, at first destroyed some of the grubs in these cells; but they clustered around two that were covered in, as if to impart warmth to the pupæ they contained; and on the following day they began to work upon the portions of comb with which he had supplied them, in order to fix and lengthen them. For two or three days the work went on very leisurely, but afterwards their labours assumed their usual character of indefatigable industry[a]. There is no difficulty, therefore, when a hive loses its sovereign, to supply the bees with an object that will interest them, and keep their works in progress.

There are a few other facts with respect to the larvæ and pupæ of the bees, which, before I enter upon the history of them in their perfect form, I shall now detail to you. Sixteen days is the time assigned to a *queen* for her existence in her preparatory states, before she is ready to emerge from her cell. Three she remains in the egg; when hatched she continues feeding five more; when covered in she begins to spin her cocoon, which occupies another day: as if exhausted by this labour, she now

[a] Reaum. v. 271—

remains perfectly still for two days and sixteen hours; and then assumes the pupa, in which state she remains exactly four days and eight hours—making in all the period I have just named. A longer time, by four days, is required to bring the *workers* to perfection; their preparatory states occupying twenty days, and those of the *male* even twenty-four. The former consumes half a day more than the queen in spinning its cocoon,—a circumstance most probably occasioned by a singular difference in the structure and dimensions of this envelope, which I shall explain to you presently. Thus you see that the peculiar circumstances which change the form and functions of a bee, accelerate its appearance as a perfect insect; and that by choosing a grub three days old, when the bees want a queen, they actually gain six days; for in this case she is ready to come forth in ten days, instead of sixteen, which would be required, was a recently laid egg fixed upon[a].

The larvæ of bees, though without feet, are not altogether without motion. They advance from their first station at the bottom of the cell, as I before hinted, in a spiral direction. This movement, for the first three days, is so slow as to be scarcely perceptible; but after this it is more easily discerned. The animal now makes two entire revolutions in about an hour and three quarters; and when the period of its metamorphosis arrives, it is scarcely more than two lines from the mouth of the cell. Its attitude, which is always the same, is a strong

[a] Huber, i. 215—. Schirach asserts, that in cold weather the disclosure of the imago takes place two days later than in warm: and Riem, that in a bad season the eggs will remain in the cells many months without hatching. Schirach, 79. 241.

curve[a]. This occasions the inhabitant of a horizontal cell to be always perpendicular to the horizon, and that of a vertical one to be parallel with it.

A most remarkable difference, as I lately observed, takes place in spinning their cocoons,—the grubs of workers and drones spinning complete cocoons, while those that are spun by the females are incomplete, or open at the lower end, and covering only the head and trunk and the first segment of the abdomen. This variation is probably occasioned by the different forms of the cells; for, if a female larva be placed in a workers cell, it will spin a complete cocoon; and, *vice versâ*, if a worker larva be placed in a royal cell, its cocoon will be incomplete[b]. No provision of the Great Author of nature is in vain. In the present instance, the fact which we are considering is of great importance to the bees; for, were the females wholly covered by the thick texture of a cocoon, their destruction by their rival competitors for the throne could not so readily be accomplished; they either would not be able to reach them with their stings, or the stings might be detained by their barbs in the meshes of the cocoon, so that they would not be able to disengage them. On the use of this instinctive and murderous hatred of their rivals I shall soon enlarge.

When our young prisoners are ready to emerge, they do not, like the ants, require the assistance of the workers, but themselves eat through the cocoon and the cell that incloses it. By a wise provision, which prevents the injury or destruction of a cell, they generally make their way through the cover or lid with which the

[a] Schirach, *t.* 3. *f.* 10. [b] Huber, i. 224.

workers had shut it up; though sometimes, but not often, a female will break through the side of her prison[a].

Having thus shown you our little chemists in their preparatory states, and carried you from the egg to the cocoon, both of which may be deemed a kind of cradle, in which they are nursed to fit them for two very different conditions of existence, I must now introduce you to a scene more interesting and diversified; in which all their wonderful instincts are displayed in full action, and we see them exceed some of the most vaunted products of human wisdom, art, and skill.

The *queen-mother* here demands our first attention, as the personage upon whom, when established in her regal dignity, the welfare and happiness of the apiarian community altogether depend. I shall begin my history with the events that befall her on her quitting the royal cradle and appearing in the perfect state. And here you will find that the first moments of her life, prior to her election to lead a swarm or fill a vacant throne, are moments of the greatest uneasiness and vexation, if not of extreme peril and vindictive and mortal warfare. The Homeric maxim, that "the government of many is not good[a]," is fully adopted and rigorously adhered to in these societies. The jealous Semiramis of the hive will bear no rival near her throne. There are usually not less than sixteen, and sometimes not less than twenty, royal cells in the same nest; you may therefore conceive what a sacrifice is made when one only is suffered to live and to reign. But here a distinction obtains which should not be over-

[a] Ουκ αγαθη ή πολυκοιρανιη, είς κοιρανος εςω.

looked: in some instances a single queen only is wanted to govern her native hive; in others several are necessary to lead the swarms. In the first case, inevitable death is the lot of all but one; in the other, as many as are wanted are preserved from destruction by the precautions taken on that occasion, under the direction of an all-wise Providence, by the workers.

I shall enlarge a little on each of these cases. In the formicary, as we have seen, rival queens live together very harmoniously without molesting each other: but there is that instinctive jealousy in a queen bee, that no sooner does she discover the existence of another in the hive, than she is put into a state of the most extreme agitation, and is not easy until she has attacked and destroyed her.

Naturalists had observed, that when there were two queens in the same hive, one of them soon perished; but some supposed (this was the opinion of Schirach and Riem) that the workers destroyed the supernumeraries. Reaumur, however, conjectured that these queens attacked each other; and his conjecture has been since confirmed by the actual observation of other naturalists. Blassiere, the translator of Schirach, tells us, as what he had himself witnessed, that the strongest queen kills her rival with her sting; and the same is asserted by Huber, whose opportunities of observation were greater than those of any of his precursors[a].

The queen that is first liberated from her confinement, and has assumed the perfect or imago state (it is to be supposed that the author is here speaking of a hive which

[a] Schirach, 209, note *. Huber, i. 170—

has lost the old queen), soon after this event goes to visit the royal cells that are still inhabited. She darts with fury upon the first with which she meets; by means of her jaws she gnaws a hole large enough to introduce the end of her abdomen, and with her sting, before the included female is in a condition to defend herself or resist her attack, she gives her a mortal wound. The workers, who remain passive spectators of this assassination, after she quits the victim of her jealousy, enlarge the breach that she has made, and drag forth the carcase of a queen just emerged from the thin membrane that envelops the pupa. If the object of her attack be still in the pupa state, she is stimulated by a less violent degree of rage, and contents herself with making a breach in the cell: when this happens, the death of the inclosed insect is equally certain, for the workers enlarge the breach, pull it out, and it perishes[a]. If it happens, as it sometimes does, that two queens are disclosed at the same time, the care of Providence to prevent the hive from being wholly despoiled of a governor is singularly manifested by a remarkable trait in their instinct, which, when mutual destruction seems inevitable, makes them separate from each other as if panic-struck. "Two young queens," says M. Huber, "left their cells one day, almost at the same moment;—as soon as they came within sight, they darted upon each other, as if inflamed by the most ungovernable anger, and placed themselves in such an attitude, that the antennæ of each were held by the jaws of its antagonist; head was opposed to head, trunk to trunk, abdomen to abdomen; and they had only to bend the ex-

[a] Huber, i. 171—

tremity of the latter, and they would have fallen reciprocal victims to each other's sting." But nature having decreed that these duels should not be fatal to both combatants, as soon as they were thus circumstanced a panic fear seemed to strike them, and they disengaged themselves, and each fled away. After a few minutes were expired, the attack was renewed in a similar manner with the same issue; till at last one suddenly seizing the other by her wing, mounted upon her and inflicted a mortal wound[a].

The combats I have here described to you took place between virgin queens; but M. Huber found that those which had been impregnated were actuated by the same animosity, and attacked royal cells with a fury equally destructive. When another fertile queen had been introduced into this hive, a singular scene ensued, which proves how well aware the workers are that they cannot prosper with two sovereigns. Soon after she was introduced, a circle of bees was formed round the stranger, not to compliment her on her arrival, or pay her the usual homage, but to confine her, and prevent her escape; for they insensibly agglomerated themselves in such numbers round her, and hemmed her in so closely, that in about a minute she was completely a prisoner. While this was transacting, what was equally remarkable, other workers assembled in clusters round the legitimate queen, and impeded all her motions; so that soon she was not more at liberty than the intruder. It seemed as if the bees foresaw the combat that was to ensue between the two rivals, and were impatient for the event; for they only confined

[a] Huber, i. 174.

them when they appeared to avoid each other. To witness the homage, respect and love that they usually manifest to their lawful ruler; the anxiety concerning her which they often exhibit; and the distrust which for a time (as we shall see hereafter) they usually show towards strange ones even when deprived of their own; one would expect that, rather than permit such a perilous combat, they would unite in the defence of their sovereign, and cause the interloper to perish under the stroke of their fatal stings. But no; the contest for empire must be between the rival candidates: no worker must interfere in any other way than that which I have described; no contending armies must fight the battles of their sovereigns, for the law of succession seems to be "*detur fortiori.*' But to return to my narrative. The legitimate queen appearing inclined to move towards that part of the comb on which her rival was stationed, the bees immediately began to retire from the space that intervened between them, so that there was soon a clear arena for the combat. When they could discern each other, the rightful queen rushing furiously upon the pretender, seized her with her jaws near the root of the wings, and, after fixing her without power of motion against the comb, with one stroke of her sting dispatched her. If ever-so-many queens are introduced into a hive, all but one will perish, and that one will have won the throne by her own unassisted valour and strength. Sometimes a strange queen attemps of herself to enter a hive: in this case the workers, who are upon the watch and who examine every thing that presents itself, immediately seize her with their jaws by the legs or wings, and hem her in so straitly with a clustered circle of guards, turning their heads on all sides

towards her, that it is impossible for her to penetrate within. If they retain her prisoner too long, she dies either from the want of food or air, but never from their stings[a].

Here you may perhaps feel curious to know, supposing the reigning queen to die or be killed, and the bees to have discovered their loss, whether they would then receive a foreigner that offers herself to them or is introduced amongst them. Reaumur says they would do this immediately[b]; but Huber, who had better means of observing them, and studied them with more undivided attention, affirms that this will not be the case, unless twenty-four hours have elapsed since the death of the old queen. Previously to this period, as if they were absorbed by grief at their calamity, or indulged a fond hope of her revival, an intruder would be treated exactly as I have described. But when the period just mentioned is passed, they will receive any queen that is presented to them with the customary homage, and she may occupy the vacant throne[c].

I must now beg you to attend to what takes place in the second case that I mentioned, where queens are wanted to lead forth swarms. Here you will, with reason, suppose that nature has instilled some instinct into the bees, by which these necessary individuals are rescued from the fury of the reigning sovereign.

Did the old queen of the hive remain in it till the young ones were ready to come forth, her instinctive jealousy would lead her to attack them all as successively produced; and being so much older and stronger, the probability is that she would destroy them; in which

[a] Huber, i. 186. [b] Reaum. v. 268. [c] Huber, i. 190.

case there could be no swarms, and the race would perish. But this is wisely prevented by a circumstance which invariably takes place—that the first swarm is conducted by this queen, and not by a newly disclosed one, as Reaumur and others have supposed. Previously to her departure, after her great laying of male eggs in the month of May, she oviposits in the royal cells when about three or four lines in length, which the workers have in the mean time constructed. These however are not all furnished in one day,—a most essential provision, in consequence of which the queens come forth successively, in order to lead successive swarms. There is something singular in the manner in which the workers treat the young queens that are to lead the swarms. After the cells are covered in, one of their first employments is to remove here and there a portion of the wax from their surface, so as to render it unequal; and immediately before the last metamorphosis takes place, the walls are so thin that all the motions of the inclosed pupa are perceptible through them. On the seventh day the part covering the head and trunk of the young female, if I may so speak, is almost entirely unwaxed. This operation of the bees facilitates her exit, and probably renders the evaporation of the superabundant fluids of the body of the pupa more easy.

You will conclude, perhaps, when all things are thus prepared for the coming forth of the inclosed female, that she will quit her cell at the regular period, which is seven days:—but you would be mistaken. Were she indeed permitted to pursue her own inclinations, this would be the case: but here the bees show how much

they are guided in their instinct by circumstances and the wants of their society; for did the new queen leave her cell, she would immediately attack and destroy those in the other cells; a proceeding which they permit, as I have before stated, when they only want a successor to a defunct or a lost sovereign. As soon therefore as the workers perceive—which the transparency of the cell permits them to do—that the young queen has cut circularly through her cocoon, they immediately solder the cleft up with some particles of wax, and so keep her a prisoner against her will. Upon this, as if to complain of such treatment, she emits a distinct sound, which excites no pity in the breasts of her subjects, who detain her a prisoner two days longer than nature has assigned for her confinement. In the interim, she sometimes thrusts her tongue through the cleft she has made, drawing it in and out till she is noticed by the workers, to make them understand that she is in want of food. Upon perceiving this they give her honey, till her hunger being satisfied she draws her tongue back—upon which they stop the orifice with wax [a].

You may think it perhaps extraordinary that the workers should thus endeavour to retard the appearance of their young females beyond its natural limit: but when I explain to you the reason for this seeming incongruity of instinct, you will adore the wisdom that implanted it. Were a queen permitted to leave her cell as soon as the natural term for it arrived, it would require some time to fit her for flight, and to lead forth a swarm; during which interval a troublesome task would be imposed

[a] Huber, i. 256.

upon the workers, who must constantly detain her a prisoner to prevent her from destroying her rivals, which would require the labours and attention of a much larger number than are necessary to keep her confined to her cell. On this account they never suffer her to come forth till she is perfectly fit to take her flight. When at length she is permitted to do this, if she approaches the other royal cells, the workers on guard seem greatly irritated against her, and pull and bite and chase her away; and she enjoys tranquillity only while she keeps at a distance from them. As her instinct is constantly urging her to attack them, this proceeding is frequently repeated. Sometimes standing in a particular and commanding attitude, she utters that authoritative sound which so much affects the bees; they then all hang down their heads and remain motionless; but as soon as it ceases, they resume their opposition. At last she becomes violently agitated, and, communicating her agitation to others, the confusion more and more increases, till a swarm leaves the hive, which she either precedes or follows. In the same manner the other young queens are treated while there are swarms to go forth; but when the hive is sufficiently thinned, and it becomes troublesome to guard them in the manner here described, they come forth unnoticed, and fight unimpeded till one alone remains to fill the deserted throne of the parent hive.—You see here the reason why the eggs that produce these queens are not laid at the same time, but after some interval, that they may come forth successively. For did they all make their appearance together, it would be a

much more laborious and difficult task to keep them from destroying each other.

When the bees thus delay the entrance of the young queens into their world, they invariably let out the oldest first; and they probably know their progress to maturity by the emission of the sound lately mentioned. The accurate Huber took the trouble to mark all the royal cells in a hive as soon as the workers had covered them in, and he found that they were all liberated according to seniority. Those first covered first emit the sound, and so on successively; whence he conjectures that this is the sign by which the workers discover their age. As their captivity, however, is sometimes prolonged to eight or ten days, this circumstance in that time may be forgotten. In this case he supposes that their tones grow stronger as they grow older, by which the workers may be enabled to distinguish them. It is remarkable that no guard is placed round the mute queens bred according to the Lusatian method, which, when the time for their appearance is come, are not detained in captivity a single moment; but, as you have heard, are left to fight, conquer, or die[a].

You must not think, however, from what I have been saying, that the old queen never destroys the young ones previously to her leading forth the earliest swarm. She is allowed the most uncontrolled liberty of action; and if she chooses to approach and destroy the royal cells, her subjects do not oppose her. It sometimes happens,

[a] Huber, i. 286.

when unfavourable weather retards the first swarm, that all the royal progeny perishes by the sting of their mother, and then no swarm takes place. It is to be observed that she never attacks a royal cell till its inhabitant is ready to assume the pupa, therefore much will depend upon their age. When they arrive at this state, her horror of these cells, and aversion to them, are extreme: she attacks, perhaps, and destroys several; but finding it too laborious, for they are often numerous, to destroy the whole, the same agitation is caused in her as if she were forcibly prevented, and she becomes disposed to depart, rather than remain in the midst of her rivals, though her own offspring.

But though the bees, in one of these cases, appear such unconcerned spectators of the destruction of royal personages, or rather, the applauders and inciters of the bloody fact; and in the other show little respect to them, put such a restraint upon their persons, and manifest such disregard to their wishes; yet when they are once acknowledged as governors of the hive, and leaders of the colony, their instinct assumes a new and wonderful direction. From this moment they become the "*publica cura*," the objects of constant and universal attention; and wherever they go, are greeted by a homage which evinces the entire devotion of their subjects. You seemed amused and interested in no slight degree by what I related in a former letter of the marked respect paid by the ants to their females[a]: but this will bear no comparison with that shown by the inhabitants of the

[a] See above, p. 56.

hive to their queen. She appears to be the very soul of all their actions, and the centre of their instincts. When they are deprived of her, or of the means of replacing her, they lose all their activity, and pursue no longer their daily labours. In vain the flowers tempt them with their nectar and ambrosial dust: they collect neither; they elaborate no wax, and build no cells; they scarcely seem to exist; and, indeed, would soon perish, were not the means of restoring their monarch put within their reach. But, if a small piece of comb containing the brood grubs of workers be given to them, all seem endued with new life: their instincts revive; they immediately set about building royal cells; they feed with their appropriate food the grubs they have selected, and every thing proceeds in the usual routine. Virgil has described this attachment of the bees to their sovereign with great truth and spirit in the following lines:

> " Lydian nor Mede so much his king adores,
> Nor those on Nilus' or Hydaspes' shores;
> The state united stands while he remains,
> But should he fall, what dire confusion reigns!
> Their waxen combs and honey, late their joy,
> With grief and rage distracted, they destroy:
> He guards the works, with awe they him surround,
> And crowd about him with triumphant sound;
> Him frequent on their duteous shoulders bear,
> Bleed, fall, and die for him in glorious war."

M. Huber thus describes the consequences of the loss of a queen.—When the queen is removed from a hive, at first the bees seem not to perceive it, their order and tranquillity not being disturbed, and their labours pro-

ceeding as usual. About an hour after her departure, inquietude begins to manifest itself amongst them; the care of the young brood no longer engages their attention, and they run here and there, as if in great agitation. This agitation, however, is at first confined to a small portion of the community. The bees that are first sensible of their loss meet with others, they mutually cross their antennæ, and strike them lightly. By this action they appear to communicate the sad intelligence to those who receive the blow, who in their turn impart it in the same way to others. Disorder and confusion increase rapidly, till the whole population is in a tumult. Then the workers may be seen running over the combs, and against each other; impetuously rushing to the entrance and quitting the hive; from thence they spread themselves all around, they re-enter, and go out again and again. The hum in the hive becomes very loud, and increases the tumult, which lasts two or three hours, rarely four or five: they then return and resume their wonted care of the young; and if the hive be visited twenty-four hours after the departure of the queen, it will be seen that they have taken steps to repair their loss by filling some of the cells with a larger quantity of jelly than is the usual portion of common larvæ; which however is intended, it seems, not for the food of the inhabitant, but for a cushion to elevate it, since it is found unconsumed in the cell when the grub is descended into the pyramidal habitation afterwards prepared for it[a].

If, after being removed, their old queen is restored to

[a] Huber, ii. 396—

the hive, they instantly recognise her, and pay her the usual attentions; but if a strange one be introduced within the first twelve hours after the old one is lost, she is kept a close prisoner till she perishes: if twenty-four hours, as I have before hinted, have expired since they lost their queen, and you introduce a new one, at the moment you set this stranger upon a comb, the workers that are near her first touch her with their antennæ, and then pass their proboscis over all parts of her body: place is next given to others, who salute her in the same manner:—all then beat their wings at the same time, and range themselves in a circle round their new sovereign. A kind of agitation is now communicated to the whole surface of the comb, which brings all the bees upon it to see what is going forward. This may be called the first shout of the applauding multitude to welcome the arrival of their new sovereign. The circle of courtiers increases, they vibrate their wings and bodies, but without tumult, as if their sensations were very agreeable. When she begins to move, the circle opens to let her pass, and all follow her steps. She is received with similar demonstrations of loyalty in the other parts of the hive, is soon acknowledged queen by all, and begins to lay eggs.—Reaumur put some bees into a hive without their queen, and then introduced to them one that he had taken when half perished with cold, and kept in a box, in which she had covered herself with powder. The bees immediately owned her for their queen, employed themselves very anxiously in cleaning her and warming her, sometimes turning her upon her back for this purpose—and then began to construct

cells in their new habitation[a]. Even when the bees have got young brood, have built or are building royal cells, and are engaged in feeding these hopes of their hive, knowing that their great aim is already accomplished, they cease all these employments when this intruder comes amongst them.

With regard to the ordinary attention and homage that they pay to their sovereigns—the bees do more than respect their queen, says Reaumur, they are constantly on the watch to make themselves useful to her, and to render her every kind office; they are for ever offering her honey; they lick her with their proboscis, and wherever she goes she has a court to attend upon her[b]. It may here be observed, that the stimulant which excites the bees to these acts of homage is the pregnant state of their queen, and her fitness to maintain the population of the hive; all they do being with a view to the public good: for while she remains a virgin she is treated with the utmost indifference, which is exchanged, as soon as impregnation has taken place, for the above marks of attachment[c].

The instinct of the bees, however, does not always enable them to distinguish a partially fertile queen from one that is universally so. What I mean is this—A queen, whose impregnation is retarded beyond the twenty-eighth day of her whole existence, lays only male eggs, which are of no use whatever to the community, unless they are at the same time provided with a sufficient supply of workers. Yet even a queen of this description,

[a] Reaum. v. 262. [b] Reaum. v. Pref. xv. [c] Huber, i. 269.

and sometimes one that is entirely sterile, is treated by them with the same respect and homage as a fertile one. This seems to evince an amiable feeling in these creatures, attachment to the person as well as to the functions of the sovereign; which is further manifested by their unwillingness at first to receive a new sovereign upon the loss or death of their old one. Nay, this respect is sometimes shown to the carcase of a defunct queen, which Huber assures us he has seen bees treat with the same attention that they had shown her when alive; for a long time preferring her inanimate corpse to the fertile queens that he offered to them[a]. He attributes this to some agreeable sensation which they experience from their queens, independent of their fecundity. But since virgin queens, as we have seen, do not excite it, more probably it is a remnant of their former attachment, first excited by her fecundity, and afterwards strengthened and continued by habit.

I may here introduce an interesting anecdote related by Reaumur, which strongly marks the attachment of bees to their queen when apparently lifeless. He took one out of the water quite motionless, and seemingly dead, which had lost part of one of its legs. Bringing it home, he placed it amongst some workers that he had found in the same situation, most of which he had revived by means of warmth; some however still being in as bad a state as the poor queen. No sooner did these revived workers perceive the latter in this wretched condition, than they appeared to compassionate her case,

[a] Huber, i. 322.

and did not cease to lick her wit' their tongues till she showed signs of returning animation; which the bees no sooner perceived, than they set up a general hum, as if for joy at the happy event. All this time they paid no attention to the workers who were in the same miserable state[a].

On a former occasion I have mentioned the laying of the eggs by the queen[b]; but as I did not then at all enlarge upon it, I shall now explain the process more in detail. In a subsequent letter I shall notice, what has so much puzzled learned apiarists—her fecundation: which is now ascertained beyond contradiction, from the observations of M. Huber, to take place in the open air, and to be followed by the death of the unfortunate male[c]. It is to be recollected that, from September to April, generally speaking, there are no males in the hives; yet during this period the queen often oviposits: a former fecundation, therefore, must fertilize all the eggs laid in this interval. The impregnation, in order to ensure complete fertility, must not be too long retarded: for, as I before observed, if this be delayed beyond the twenty-eighth day of her existence, her ovaries become so vitiated, that she can no longer lay eggs that will produce workers, but can only furnish the hive with a male population; which, however high a privilege it may be accounted amongst men, is the reverse of it amongst the bees. When this is the case, the abdomen of the queen becomes so enlarged that she is no longer able to fly[d]; and, what is remarkable, she loses that instinc-

[a] Reaum. v. 265. [b] Vol. I. 4th Ed. 375, 376.
[c] Huber, i. 63— [d] Schirach, 257.

tive animosity which stimulates the fertile ones to attack their rivals [a]. Thus she seems to own that she is not equal to the duties of her station, and can tolerate another to discharge them in her room. When we consider how much virgin queens are slighted by their subjects, we may suppose that nature urges them to take the opportunity of the first warm day, when the males fly forth, to pair with one of them.

When fecundation has not been retarded, forty-six hours after it has taken place, the queen begins to lay eggs that will produce workers, and continues for the subsequent eleven months, more or less, to lay them solely; and it is only after this period that an uninterrupted laying of male eggs commences.—But when it has been retarded, after the same number of hours she begins laying male eggs, and continues to produce these alone during her whole life. From hence it should seem to follow, that the former kind of eggs are first in the oviducts, and, if impregnation be not effected within a given time, that all the worker embryos perish. Yet how this can take place with respect to those that in a fertile queen should succeed the laying of male eggs, or be produced in the second year of her life, seems difficult to conceive;—or how the male embryos escape this fate, which destroys all the females, both those that are to precede them and those that are to follow them. Is it impossible that the sex of the embryo may be determined by the period at which the *aura seminalis* vivifies it, and by the state of the ovary at that time? In

[a] Huber, i. 319—

one state of the ovary this principle may cause the embryos to become workers, in another males. And something of this kind perhaps may be the cause of hermaphrodites in other animals. But this I give merely as conjecture[a]: the truth seems enveloped in mystery that we cannot yet penetrate. Huber is of opinion that a single impregnation fertilizes all the eggs that a queen will produce during her whole life, which is sometimes more than two years[b]. But of this enough.

I said that forty-six hours after impregnation the queen begins laying worker eggs;—this is not, however, invariable. When her impregnation takes place late in the year, she does not begin laying till the following spring. Schirach asserts, that in one season a single female will lay from 70,000 to 100,000 eggs[c]. Reaumur says, that upon an average she lays about two hundred in a day, a moderate swarm consisting of 12,000, which are laid in two months; and Huber, that she lays above a hundred. All these statements, the observations being made in different climates, and perhaps under different circumstances, may be true. The laying of worker eggs begins in February, sometimes so early as January[d]. After this, in the spring, the great laying of male eggs com-

[a] This conjecture receives strong confirmation from the following observations of Sir E. Home, which I met with since it came into my mind. From the nipples present in man, which sometimes even afford milk, and from the general analogy between the male and female organs of generation, he supposes the germ is originally fitted to become either sex; and that which it shall be is determined at the time of impregnation by some unknown cause. *Philos. Trans.* 1799. 157.

[b] i. 106— [c] Schirach, 7. 13. [d] Ibid. 13. Thorley, 105.

mences, lasting thirty days; in which time about 2,000 of these eggs are laid. Another laying of them, but less considerable, takes place in autumn. In the season of oviposition, the queen may be discerned traversing the combs in all directions with a slow step, and seeking for cells proper to receive her eggs. As she walks, she keeps her head inclined, and seems to examine, one by one, all the cells she meets with. When she finds one to her purpose, she immediately gives to her abdomen the curve necessary to enable it to reach the orifice of the cell, and to introduce it within it. The eggs are set in the angle of the pyramidal bottom of the cell, or in one of the hollows formed by the conflux of the sides of the rhombs, and, being besmeared with a kind of gluten, stand upright. If, however, it be a female that lays only male eggs, they are deposited upon the lowest of the sides of the cell, as she is unable to reach the bottom[a].

While our prolific lady is engaged in this employment, her court consists of from four to twelve attendants, which are disposed nearly in a circle, with their heads turned towards her. After laying from two to six eggs, she remains still, reposing for eight or nine minutes. During this interval the bees in her train redouble their attentions, licking her fondly with their tongues. Generally speaking, she lays only one egg in a cell; but when she is pressed, and there are not cells enough, from two to four have been found in one. In this case, as if they were aware of the consequences, the provident workers remove all but one. From an experiment of Huber's, it appears that the instinct of the queen invariably directs her to deposit worker eggs in worker cells; for when he confined one,

[a] Bonnet, x. 258, 8vo ed.

during her course of laying worker eggs, where she could only come at male cells, she refused to oviposit in them; and trying in vain to make her escape, they at length dropped from her; upon which the workers devoured them. Retarded queens, however, lose this instinct, and often, though they lay only male eggs, oviposit in worker cells, and even in royal ones. In this latter case the workers themselves act as if they suffered in their instinct from the imperfect state of their queen; for they feed these male larvæ with royal jelly, and treat them as they would a real queen. Though male eggs deposited in worker cells produce small males, their education in a royal cell with "royal dainties" adds nothing to their ordinary dimensions [a].

The *swarming* of bees is a very curious and interesting subject, to which, since a female is the *sine quâ non* on this occasion, I may very properly call your attention here. You will recollect that I said something upon the principle of emigrations, when I was amusing you with the history of ants [b]; but the object with them seems to be merely a change of station for one more convenient or less exposed to injury, and not to diminish a superabundant population. Whereas, in the societies of the hive-bee, the latter is the general cause of emigrations, which invariably take place every year, if their numbers require it; if not, when the male eggs are laid, no royal cells are constructed, and no swarm is led forth. What might be the case with ants, were they confined to hives, we cannot say. Formicaries in general are ca-

a Huber, i. 122—

b See above, p. 57.

pable of indefinite enlargement, therefore want of room does not cause emigration;—but bees being confined to a given space, which they possess not the means of enlarging,—to avoid the ill effects resulting from being too much crowded, when their population exceeds a certain limit, they must necessarily emigrate. Sometimes—for instance, when wasps have got into a hive—the bees will leave it, in order to fly from an inconvenience or enemy which they cannot otherwise avoid; but it does not very often happen that they wholly desert a hive.

Apiarists tell us that, in this country, the best season for swarming is from the middle of May to the middle of June; but swarms sometimes occur so early as the beginning of April, and as late as the middle of August[a]. The first swarm, as I before observed, is led by the reigning queen, and takes place when she is so much reduced in size, in consequence of the number of eggs she has laid, (for previously to oviposition her gravid body is so heavy that she can scarcely drag it along,) as to enable her to fly with ease. The most indubitable sign that a hive is preparing to swarm,—so says Reaumur,—is when on a sunny morning, the weather being favourable to their labours, few bees go out of a hive, from which on the preceding day they had issued in great numbers, and little pollen is collected. This circumstance, he observes, must be very embarrassing to one who attempts to explain all their proceedings upon principles purely mechanical. Does it not prove, he asks, that all the inhabitants of a hive, or almost all, are aware

[a] Keys *On Bees*, 76.

of a project that will not be put in execution before noon, or some hours later? For why should bees, who worked the day before with so much activity, cease their labours in a habitation which they are to quit at noon, were they not aware that they should soon abandon it[a]? The appearance of the males, and the clustering of the population at the mouth of the hive, (though this last is less to be relied upon, being often occasioned by extreme heat,) are also indications of the approach of this event. A good deal depends, however, on the warmth of the atmosphere and the state of the weather either to accelerate or retard it. Another sign is a general hum in the evening, which is continued even during the night,—all seems to be in a bustle, the greatest restlessness agitates the bees. Sometimes to hear this hum the ear must be placed close to the hive, when clear and sharp sounds may be distinguished, which appear to be produced by the vibration of the wings of a single bee. This hum by some has been gravely construed into an harangue of the queen to animate her subjects to the great undertaking which she now meditates—the founding of a new empire. There sometimes seem to happen suddenly amongst them, says Reaumur, events which put all the bees in motion, for which no account can be given. If you observe a hive with attention, you may often remain a long time and hear only a slight murmur, and then, all in a moment, a sonorous hum will be excited, and the workers, as if seized with a panic terror, may be seen quitting their various labours, and running off in

[a] Reaum. v. 611.

different directions. At these moments if a young queen goes out, she will be followed by a numerous troop.

Huber has given a very lively and interesting account of the interior proceedings of the hive on this occasion. The queen, as soon as she began to exhibit signs of agitation, no longer laid her eggs with order as before, but irregularly, as if she did not know what she was about. She ran over the bees in her way; they in their turn struck her with their antennæ, and mounted upon her back; none offered her honey, but she helped herself to it from the cells in her path. The usual homage of a court attending round her was no longer paid. Those however that were excited by her motions followed her, rousing such as were still tranquil upon the combs. She soon had traversed the whole hive, when the agitation became general. The workers, now no longer attentive to the young brood, ran about in all directions; even those that returned from foraging, before the agitation was at its height, no sooner entered the hive than they participated in these tumultuous movements, and, neglecting to free themselves from the masses of pollen on their hind legs, ran wildly about. At length there was a general rush to the outlets of the hive, which the queen accompanied, and the swarm took place[a].

It is to be observed that this agitation, excited by the queen, increases the customary heat of the hive to a very high temperature, which the action of the sun augments till it becomes intolerable, and which often causes the bees accumulated near the mouth of the hive to perspire

[a] Huber, i. 251.

so copiously, that those near the bottom, who support the weight of the rest, appear drenched with the moisture. This intolerable heat determines the most irresolute to leave the hive. Immediately before the swarming, a louder hum than usual is heard, many bees take flight, and, if the queen be at their head, or soon follows them, in a moment the rest rise in crowds after her into the air, and the element is filled with bees as thick as the falling snow. The queen at first does not alight upon the branch on which the swarm fixes; but as soon as a group is formed and clustered, she joins it: after this it thickens more and more, all the bees that are in the air hastening to their companions and their queen, so as to form a living mass of animals supporting themselves upon each by the claws of their feet. Thus they sometimes are so concatenated, each bee suspending its legs to those of another, as to form living chaplets[a]. After this they soon become tranquil, and none are seen in the air. Before they are housed they often begin to construct a little comb on the branch on which they alight[b]. Sometimes it happens that two queens go out with the same swarm; and the result is, that the swarm at first divides into two bodies, one under each leader; but as one of these groups is generally much less numerous than the other, the smallest at last joins the largest, accompanied by the queen to whom they had attached

[a] Some critics have found fault with Mr. Southey for ascribing, in his *Curse of Kehama*, to Camdeo, the Cupid of Indian mythology, a bow strung with bees. The idea is not so absurd as they imagine; and the poet doubtless was led to it by his knowledge of the natural history of these animals, and that they form themselves into strings or chaplets.—See Reaum. v. *t.* xxii. *f.* 3.

[b] Reaumur, 615-644.

themselves; and, when they are hived, this unfortunate candidate for empire falls sooner or later a victim to the jealousy of her rival. Till this great question is decided, the bees do not settle to their usual labours[a]. If no queen goes out with a swarm, they return to the hive from whence they came.

As in regular monarchies, so in this of the bees, the first-born is probably the fortunate candidate for the throne. She is usually the most active and vigorous; the most able to take flight; and in the best condition to lay eggs. Though the queen that is victorious, and mounts the throne, is not, as Virgil asserts, resplendent with gold and purple, and her rival hideous, slothful and unwieldy[b], yet some differences are observable; the successful candidate is usually redder and larger than the others; these last, upon dissection, appear to have no eggs ready for laying, while the former, which is a powerful recommendation, is usually full of them. Eggs are commonly found in the cells twenty-four hours after swarming, or at the latest two or three days.

You may think, perhaps, that the bees which emigrate from the parent hive are the youth of the colony; but this is not the case, for bees of all ages unite to form the swarms. The numbers of which they consist vary much. Reaumur calls 12,000 a moderate swarm; and

[a] Reaumur, 615-644.

[b] "Alter erit maculis auro squalentibus ardens,
(Nam duo sunt genera) hic melior, insignis et ore,
Et rutilis clarus squamis: ille horridus alter
Desidiâ, latamque trahens inglorius alvum."
Georg. iv. 91—

he mentions one which amounted to more than three times that number (40,000). A swarm seldom or never takes place except when the sun shines and the air is calm. Sometimes, when every thing seems to prognosticate swarming, a cloud passing over the sun calms the agitation; and afterwards, upon his shining forth again, the tumult is renewed, keeps augmenting, and the swarm departs[a]. On this account the confinement of the queens, before related, is observed to be more protracted in bad weather.

The longest interval between the swarms is from seven to nine days, which usually is the space that intervenes between the first and the second. The next flies sooner, and the last sometimes departs the day after that which preceded it. Fifteen or eighteen days, in favourable weather, are usually sufficient for throwing the four swarms. The old queen, when she takes flight with the first swarm, leaves plenty of brood in the cells, which soon renew the population[b].

It is not without example, though it rarely happens, that a swarm conducted by the old queen increases so much in the space of three weeks as to send forth a new colony. Being already impregnated, she is in a condition to oviposit as soon as there are cells ready to receive her eggs: and an all-wise Providence has so ordered it, that at this time she lays only such as produce workers. And it is the first employment of her subjects to con-

[a] Bees are generally thought to foresee the state of the weather: but they are not always right in their prognostics; for Reaumur witnessed a swarm, which after leaving the hive at half-past one o'clock were overtaken by a very heavy shower at three.

[b] Huber, i. 271.

struct cells for this purpose[a]. The young queens that conduct the secondary swarms usually pair the day after they are settled in their new abode; when the indifference with which their subjects have hitherto treated them is exchanged for the usual respect and homage.

We may suppose that one motive with the bees for following the old queen, is their respect for her; but the reasons that induce them to follow the virgin queens, to whom they not only appear to manifest no attachment, but rather the reverse, seem less easy to be assigned. Probably the high temperature of the hive during these times of tumultuous agitation may be the principal cause that operates upon them. In a populous hive the thermometer commonly stands between 92° and 97°; but during the tumult that precedes swarming it rises above 104°, a heat intolerable to these animals[b]. This is M. Huber's opinion. Yet still, though a high temperature will well account for the departure of the swarm from the hive with a virgin queen, if there were really no attachment, (as he appears to think,) is it not extraordinary, that when this cause no longer operates upon them, they should agglomerate about her, as they always do, be unsettled and agitated without her, and quiet when she is with them? Is it not reasonable to suppose that the instinct which teaches them what is necessary for the preservation of their society,—at the same time that it shows them that without a queen that society cannot be preserved,—impells them in every case to the mode of treating her which will most effectually influence her

[b] Huber, i. 305. [a] Ibid. 280.

conduct, and give it that direction which is most beneficial to the community?

Yet, with respect to the treatment of queens, instinct does not invariably direct the bees to this end. There are certain exceptions, produced perhaps by artifici al casual occurrences, in which it seems to deviate, yet as we should call it amiably, from the rule of the public advantage. Retarded queens, which, as I have observed, lay male eggs only, deposit them in all cells indifferently, even in royal ones. These last are treated by the workers as if they were actually to become queens. Here their instinct seems defective:—it appears unaccountable that they should know these eggs, as they do, when deposited in workers cells, and give them a convex covering when about to assume the pupa; unless, perhaps, the size of the larva directs them in this case.

The amputation of one of the antennæ of a queen bee appears not to affect her perceptibly; but cutting off both these important organs produces a very striking derangement of all her proceedings—She seems in a species of delirium, and deprived of all her instincts; every thing is done at random; yet the respect and homage of the workers towards her, though they are received by her with indifference, continue undiminished. If another in the same condition be put in the hive, the bees do not appear to discover the difference, and treat them both alike: but if a perfect one be introduced, even though fertile, they seize her, keep her in confinement, and treat her very unhandsomely. One may conjecture from this circumstance, that it is by those wonderful organs, the antennæ, that the bees know their own queen.

If two mutilated queens meet, they show not the slightest symptom of resentment. While one of these continues in the hive, the workers never think of choosing another; but if she leaves it, they do not accompany her, probably because the heat is not increased by her putting them into the preparatory agitation[a].

I am, &c.

[a] Huber, i. 316.

LETTER XX.

SOCIETIES OF INSECTS.

PERFECT SOCIETIES CONCLUDED.

HAVING given you a history sufficiently ample of the queen or female bee, I shall next add some account of the *drone* or *male bee*; but this will not detain you long, since, "to be born and die" is nearly the sum total of their story. Much abuse, from the earliest times, has been lavished upon this description of the inhabitants of the hive, and their indolence and gluttony have become proverbial.—Indeed, at first sight, it seems extraordinary that seven or eight hundred individuals should be supported at the public expense, and to common appearance do nothing all the while that may be thought to earn their living. But the more we look into nature, the more we discover the truth of that common axiom, —that nothing is made in vain.—Creative Wisdom cannot be caught at fault. Therefore, where we do not at present perceive the reasons of things, instead of cavilling at what we do not understand, we ought to adore in silence, and wait patiently till the veil is removed which, in any particular instance, conceals its final cause from our sight. The mysteries of nature are gradually

opened to us, one truth making way for the discovery of another: but still there will always be in nature, as well as in revelation, even in those things that fall under our daily observation, mysteries to exercise our faith and humility: so that we may always reply to the caviller,—"Thine own things and those that are grown up with thee hast thou not known; how then shall thy vessel comprehend the way of the Highest?"

Various have been the conjectures of naturalists, even in very recent times, with respect to the fertilization of the eggs of the bee. Some have supposed,—and the number of males seemed to countenance the supposition,—that this was effected after they were deposited in the cells. Of this opinion Maraldi seems to have been the author, and it was adopted by Mr. Debraw of Cambridge, who asserts that he has seen the smaller males (those that are occasionally produced in cells usually appropriated to workers) introduce their abdomen into cells containing eggs, and fertilize them; and that the eggs so treated proved fertile, while others that were not remained sterile. The common or large drones, which form the bulk of the male population of the hive, could not be generally destined to this office, since their abdomen, on account of its size, could only be introduced into male and royal cells. Bonnet, however, saw some motions of one of these drones, which, while it passed by those that were empty, appeared to strike with its abdomen the mouth of the cells containing eggs[a]. Swammerdam thought that the female was impregnated by effluvia which issued from the male[b]. Reaumur, from

[a] Bonnet, x. 259. [b] *Bibl. Nat.* i. 221. *b.* ed. Hill.

some proceedings that he witnessed, was convinced that impregnation took place according to the usual law of nature, and, as he supposed, within the hive[a]. This opinion Huber has confirmed by indubitable proofs; but he further discovered that these animals pair abroad, in the air, during the flight of the queen: a fact which renders a large number of males necessary, to ensure her impregnation in due time to lay eggs that will produce workers[b]. Huber also observed those appearances which induced Debraw to adopt the opinion I mentioned just now, and was at first disposed to think them real; but afterwards, upon a nearer inspection, he discovered that it was an illusion caused by the reflection of the rays of light[c].

In fine weather the drones, during the warmest part of the day, take their flights; and it is then that they pair with the queen in mid air, the result being invariably the death of the drone. No one has yet discovered, unless the proceedings observed by Debraw and Bonnet may be so interpreted, that when in the hive they take any share in the business of it, their great employment within doors being to eat. Their life however is of very short duration, the eggs that produce drones being laid in the course of April and May, and their destruction being usually accomplished in the months of July and August. The bees then, as M. Huber observes, chase them about, and pursue them to the bottom of the hives, where they assemble in crowds. At the same time numerous carcases of drones may be seen on the ground before the hives. Hence he conjectured, though he

[a] Reaum. v. 503— [b] Huber, i. 24— [c] Ibid. 37—

never could detect them engaged in this work upon the combs, that they were stung to death by the workers. To ascertain how their death was occasioned, he caused a table to be glazed, on which he placed six hives, and under this table he employed the patient and indefatigable Burnens, who was to him instead of eyes, to watch their proceedings. On the fourth of July this accurate observer saw the massacre going on in all the hives at the same time, and attended by the same circumstances. The table was crowded with workers, who, apparently in great rage, darted upon the drones as soon as they arrived at the bottom of the hive, seizing them by their antennæ, their legs, and their wings; and killing them by violent strokes of their sting, which they generally inserted between the segments of the abdomen. The moment this fearful weapon entered their body, the poor helpless creatures expanded their wings and expired. After this, as if fearful that they were not sufficiently dispatched, the bees repeated their strokes, so that they often found it difficult to extricate their sting. On the following day they were equally busy in the work of slaughter; but their fury, their own having perished, was chiefly vented upon those drones, which, after having escaped from the neighbouring hives, had sought refuge with them. Not content with destroying those that were in the perfect state, they attacked also such male pupæ as were left in their cells; and then dragging them forth, sucked the fluid from their bodies and cast them out of the hive[a].

But though in hives containing a queen perfectly fer-

[a] Huber, i. 195.

tile (that is, which lay both worker and male eggs,) this is the unhappy fate of the drones; yet in those where the queen only lays male eggs, they are suffered to remain unmolested; and in hives deprived of their queen, they also find a secure asylum[a].

What it is that, in the former instance, excites the fury of the bees against the males, is not easy to discover; but some conjecture may perhaps be formed from the circumstances last related. When only males are produced by the queen, the bees seem aware that something more is wanted, and retain the males; the same is the case when they have no queen; and when one is procured, they appear to know that she would not profit them without the males. Their fury then is connected with their utility: when the queen is impregnated, which lasts for her whole life, as if they knew that the drones could be of no further use, and would only consume their winter stores of provision, they destroy them; which surely is more merciful than expelling them, in which case they must inevitably perish from hunger. But when the queen only produces males, their numbers are not sufficient to cause alarm; and the same reasoning applies to the case when there is no queen.

Having brought the males from their cradle to their untimely grave, and amused you with the little that is known of their uneventful history, I shall now, at last, call you to attend to the proceedings of the *workers* themselves; and here I am afraid, long as I have detained you, I must still press you to expatiate with me in a

[a] Huber, i. 199.

more ample field; but the spectacles you will behold during our excursion will repay, I promise you, any delay or trouble it may occasion.

When I consider the proceedings of these little creatures, both in the hive and out of it, they are so numerous and multifarious, that I scarcely know where to begin. You have already, however, heard much of their internal labours, in the care and nurture of the young; the construction of their combs[a]; and their proceedings with respect to their queens and their paramours. It will therefore change the scene a little, if we accompany them in their excursions to collect the various substances of which they have need[b]. On these occasions the principal object of the bees is to furnish themselves with three different materials:—the nectar of flowers, from which they elaborate honey and wax; the pollen or fer-

[a] Vol. I. 4th Ed. 375—and 484—

[b] The following beautiful lines by Professor Smyth are extremely applicable to this part of a bee's labours:

"Thou cheerful Bee! come, freely come,
And travel round my woodbine bower!
Delight me with thy wandering hum,
And rouse me from my musing hour;
Oh! try no more those tedious fields,
Come taste the sweets my garden yields:
The treasures of each blooming mine,
The bud, the blossom,—all are thine.

"And careless of this noon-tide heat,
I'll follow as thy ramble guides;
To watch thee pause and chafe thy feet,
And sweep them o'er thy downy sides:
Then in a flower's bell nestling lie,
And all thy envied ardor ply!
Then o'er the stem, tho' fair it grow,
With touch rejecting, glance, and go.

"O Nature

tilizing dust of the anthers, of which they make what is called bee-bread, serving as food both to old and young; and the resinous substance called by the ancients *Propolis*, *Pissoceros*, &c. used in various ways in rendering the hive secure and giving the finish to the combs. The first of these substances is the pure fluid secreted in the nectaries of flowers, which the length of their tongue enables them to reach in most blossoms. The tongue of a bee, you are to observe, though so long and sometimes so inflated[a], is not a tube through which the honey passes, nor a pump acting by suction, but a real tongue which laps or licks the honey, and passes it down on its upper surface, as we do, to the mouth, which is at its base concealed by the mandibles[b]. It is conveyed by this orifice through the œsophagus into the first stomach, which we call the honey-bag, and which, from being very small, is swelled when full of it to a considerable size. Honey is never found in the second stomach, (which is surrounded with muscular rings, and resembles a cask covered with hoops from one end to the other,) but only in the first: in the latter and the intestines the bee-bread only is discovered. How the wax is secreted, or what vessels are appropriated to that purpose, is not yet ascertained. Huber suspects that a cel-

"O Nature kind! O labourer wise!
That roam'st along the summer's ray,
Glean'st every bliss thy life supplies,
And meet'st prepared thy wintry day!
Go, envied go—with crowded gates
The hive thy rich return awaits;
Bear home thy store, in triumph gay,
And shame each idler of the day."

[a] Reaum. v. *t.* xxviii. *f.* l. 2. [b] Ibid. *f.* 7. *o.*

lular substance, consisting of hexagons, which lines the membrane of the wax-pockets, may be concerned in this operation. This substance he also discovered in humble-bees (which though they make wax have no wax-pockets), occupying all the anterior part or base of the segments[a]. If you wish to see the wax-pockets in the hive-bee, you must press the abdomen so as to cause it to extend itself; you will then find on each of the four intermediate ventral segments, separated by the carina or elevated central part, two trapeziform whitish pockets, of a soft membranaceous texture: on these the laminæ of wax are formed, and they are found upon them in different states, so as to be more or less perceptible. I must here observe that, besides Thorley, who seems to have been the first apiarist that observed these laminæ, Wildman was not ignorant of them, nor of the wax being formed from honey[b]: we must not therefore permit foreigners to appropriate to themselves the whole credit of discoveries that have been made, or at least partially made, by our own countrymen.

Long before Linné had discovered the nectary of flowers, our industrious creatures had made themselves intimate with every form and variety of them; and no botanist, even in this enlightened era of botanical science, can compare with a bee in this respect. The station of these reservoirs, even where the armed sight of science cannot discover it, is in a moment detected by the microscopic eye of this animal.

She has to attend to a double task—to collect materials for bee-bread as well as for honey and wax. Ob-

[a] Huber, ii. 5 – . *t.* ii. *f.* 8. [b] Wildman, 43.

serve a bee that has alighted upon an open flower. The hum produced by the motion of her wings ceases, and her employment begins. In an instant she unfolds her tongue, which before was rolled up under her head. With what rapidity does she dart this organ between the petals and the stamina! At one time she extends it to its full length, then she contracts it; she moves it about in all directions, so that it may be applied both to the concave and convex surface of a petal, and wipe them both; and thus by a virtuous theft robs it of all its nectar. All the while this is going on, she keeps herself in a constant vibratory motion. The object of the industrious animal is not, like the more selfish butterfly, to appropriate this treasure to herself. It goes into the honey-bag as into a laboratory, where it is transformed into pure honey; and when she returns to the hive, she regurgitates it in this form into one of the cells appropriated to that purpose; in order that, after tribute is paid from it to the queen, it may constitute a supply of food for the rest of the community.

In collecting honey, bees do not solely confine themselves to flowers, they will sometimes very greedily absorb the sweet juices of fruits: this I have frequently observed with respect to the raspberries in my garden, and have noticed it, as you may recollect, in a former letter[a]. They will also eat sugar, and produce wax from it; but from Huber's observations, it appears not calculated to supply the place of honey in the jelly with which the larvæ are fed[b]. Though the great mass of the food of bees is collected from flowers, they do not

[a] Vol. I. 4th Ed. 194. [b] Huber, ii. 82.

wholly confine themselves to a vegetable diet; for, besides the honeyed secretion of the Aphides, the possession of which they will sometimes dispute with the ants[a], upon particular occasions they will eat the eggs of the queen. They are very fond also of the fluid that oozes from the cells of the pupæ, and will suck eagerly all that is fluid in their abdomen after they are destroyed by their rivals[b].—Several flowers that produce much honey they pass by; in some instances, from inability to get at it. Thus, for this reason probably, they do not attempt those of the trumpet-honey-suckle, (*Lonicera sempervirens*, L.) which, if separated from the germen after they are open, will yield two or three drops of the purest nectar. So that were this shrub cultivated with that view, much honey in its original state might be obtained from a small number of plants. In other cases, it appears to be the poisonous quality of their honey that induces bees to neglect certain flowers. You have doubtless observed the conspicuous white nectaries of the crown imperial, (*Fritillaria imperialis*, L.) and that they secrete abundance of this fluid. It tempts in vain the passing bee, probably aware of some noxious quality that it possesses. The oleander (*Nerium Oleander*, L.) yields a honey that proves fatal to thousands of imprudent flies; but our bees, more wise and cautious, avoid it. Occasionally, perhaps, in particular seasons, when flowers are less numerous than common, this instinct of the bees appears to fail them, or to be overpowered by their desire to collect a sufficient store of honey for their purposes, and they suffer for their want of self-denial.

[a] Abbé Boisier, quoted in Mills *on Bees*, 24.
[b] Schirach, 45. Huber, i. 179.

Sometimes whole swarms have been destroyed by merely alighting upon poisonous trees. This happened to one in the county of West Chester in the province of New York, which settled upon the branches of the poison-ash (*Rhus Vernix*, L.). In the following morning the imprudent animals were all found dead, and swelled to more than double their usual size[a]. Whether the honey extracted from the species of the genus *Kalmia*, *Andromeda*, *Rhododendron*, &c. be hurtful to the bees themselves, is not ascertained; but, as has been before observed, it is often poisonous to man[b]. The Greeks, as you probably recollect, in their celebrated retreat after the death of the younger Cyrus, found a kind of honey at Trebisond on the Euxine coast, which, though it produced no fatal effects upon them, rendered those who ate but little, like men very drunk, and those who ate much, like mad men or dying persons; and numbers lay upon the ground as if there had been a defeat. Pliny, who mentions this honey, calls it *mænomenon*, and observes that it is said to be collected from a kind of *Rhododendron*, of which Tournefort noticed two species there[c].

When the stomach of a bee is filled with nectar, it next, by means of the feathered hairs[d] with which its body is covered, pilfers from the flowers the fertilizing dust of the anthers, the *pollen*; which is equally necessary to the society with the honey, and may be named the ambrosia of the hive, since from it the bee-bread is made. Sometimes a bee is so discoloured with this powder as to look like a different insect, becoming white, yellow, or

[a] Nicholson's *Journal*, xxiii. 287. [b] Vol. I. 4th Ed. 142.

[c] Xenoph. *Anabas*. l. iv. Plin. *Hist. Nat*. l. xxi. c. 13.

[d] Reaum. v. *t*. xxvi. *f*. l.

orange, according to the flowers in which it has been busy. Reaumur was urged to visit the hives of a gentleman, who on this account thought his bees were different from the common kind[a]. He suspected, and it proved, that the circumstance just mentioned occasioned the mistaken notion. When the body of the bee is covered with farina, with the brushes of its legs, especially of the hind ones, it wipes it off: not, as we do with our dusty clothes, to dissipate and disperse it in the air, but to collect every particle of it, and then to knead it and form it into two little masses, which she places, one in each, in the baskets formed by hairs[b] on her hind legs.

Aristotle says that in each journey from the hive, bees attend only one species of flower[c]; Reaumur, however, seems to think that they fly indiscriminately from one to another: but Mr. Dobbs in the *Philosophical Transactions*[d], and Butler before him, asserts that he has frequently followed a bee engaged in collecting pollen, &c. and invariably observed that it continued collecting from the same kind of flowers with which it first began: passing over other species, however numerous, even though the flower it first selected was scarcer than others. His observations, he thinks, are confirmed—and the idea seems not unreasonable—by the uniform colour of the pellets of pollen, and their different size. Reaumur himself tells us that the bees enter the hive, some with yellow pellets, others with red ones, others again with whitish ones, and that sometimes they are even green: upon which he observes, that this arises from their being collected from

[a] Reaum 295.
[b] Kirby, *Monogr. Ap. Angl.* i. *t.* 12. **. e. 1. *neut.* f. 19. *a. b.*
[c] *Hist. Anim.* l. ix. c. 40.
[d] xlvi. 536.

particular flowers, the pollen of whose anthers is of those colours[a]. Sprengel, as before intimated[b], has made an observation similar to that of Dobbs. It seems not improbable that the reason why the bee visits the same species of plants during one excursion may be this:—Her instinct teaches her that the grains of pollen which enter into the same mass should be homogeneous, in order perhaps for their more effectual cohesion; and thus Providence also secures two important ends,—the impregnation of those flowers that require such aid, by the bees passing from one to another; and the avoiding the production of hybrid plants, from the application of the pollen of one kind of plant to the stigma of another. When the anthers are not yet burst, the bee opens them with her mandibles, takes a parcel of pollen, which one of the first pair of legs receives and delivers to the middle pair, from which it passes to one of the hind legs.

If the contents of one of the little pellets be examined under a lens, it will be found that the grains have all retained their original shape. A botanist practised in the figure of the pollen of the different species of common plants might easily ascertain, by such an examination, whether a bee had collected its ambrosia from one or more, and also from what species of flowers.

In the months of April and May, as Reaumur tells us, the bees collect pollen from morning to evening; but in the warmer months the great gathering of it is from the time of their first leaving the hive (which is sometimes so early as four in the morning) to about 10 o'clock A. M. About that hour all that enter the hive may be seen with their pellets in their baskets; but during the rest of the

[a] *ubi supra*, 301. [b] Vol. I. 4th Ed. 295.

day the number of those so furnished is small in comparison of those that are not. In a hive, however, in which a swarm is recently established, it is generally brought in at all parts of the day. He supposes, in order for its being formed into pellets, that it requires some moisture, which the heat evaporates after the above hour; but in the case of recently colonized hives, that the bees go a great way to seek it in moist and shady places[a].

When a bee has completed her lading, she returns to the hive to dispose of it. The honey is disgorged into the honey-pots or cells destined to receive it, and is discharged from the honey-bag by its alternate contraction and dilatation. A cell will contain the contents of many honey-bags. When a bee comes to disgorge the honey, with its fore legs it breaks the thick cream that is always on the top, and the honey which it yields passes under it. This cream is honey of a thicker consistence than the rest, which rises to the top in the cells like cream on milk: it is not level, but forms an oblique surface over the honey. The cells, as you know, are usually horizontal, yet the honey does not run out. The cream, aided probably by the general thickness of the honey and the attraction of the sides of the cell, prevents this. Bees, when they bring home the honey, do not always disgorge it; they sometimes give it to such of their companions as have been at work within the hive[b]. Some of the cells are filled with honey for daily use, and some with what is intended for a

[a] Reaum. v. 302.—comp. 433. I have seen bees out before it was light.

[b] Huber observes that the honey for store is collected by the wax-making bees only (*abeilles cirières*), and that the nurses (*abeilles nourrices*) gather no more than what is wanted for themselves and companions at work in the hive. ii. 66.

reserve, and stored up against bad weather or a bad season: these are covered with a waxen lid[a].

The pollen is employed as circumstances direct. When the bee laden with it arrives at the hive, she sometimes stops at the entrance, and very leisurely detaching it by piecemeal, devours one or both the pellets on her legs, chewing them with her jaws, and passing them then down the little orifice before noticed. Sometimes she enters the hive, and walks upon the combs; and whether she walks or stands, still keeps beating her wings. By the noise thus produced, which seems a call to some of her fellow-citizens, three or four go to her, and placing themselves around her, begin to lighten her of her load, each taking and devouring a small portion of her ambrosia: this they repeat, if more do not arrive to assist them, three or four times, till the whole is disposed of[b]. Wildman observed them on this occasion supporting themselves upon their two fore feet; and making several motions with their wings and body to the right and left, which produced the sound that summoned their assistants[c]. This bee-bread, as I said before, is generally found in the second stomach and intestines, but the honey never; which induced Reaumur to think (but he was mistaken) that the bees elaborated wax from it: and he observes, that the bees devour this when they are busily engaged in constructing combs[d]. When more pollen is collected than the bees have immediate occasion for, they store it up in some of the empty cells. The laden bee puts her two hind legs into the cell, and with the inter-

[a] Reaum. v. 448. [b] Ibid. v. 418—
[c] p. 38. [d] *ubi supr.* 419.

mediate pair pushes off the pellets. When this is done, she, or another bee if she is too much fatigued with her day's labour, enters the cell with her head first, and remains there some time: she is engaged in diluting the pellets, kneading them, and packing them close; and so they proceed till the cell is filled[a]. A large portion of the cells of some combs are filled with this bread, which one while is found in insulated cells, at another in cells amongst those that are filled with honey or brood.—Thus it is everywhere at hand for use.

You have seen how the bees collect and employ two of the materials that I mentioned; I must now advert to the third—the *Propolis*. Huber was a long time uncertain from whence the bees procured this gummy resin; but it at last occurred to him to plant some cuttings of a species of poplar (before their leaves were developed, when their leaf-buds were swelling, and besmeared and filled with a viscid juice,) in some pots, which he placed in the way of the bees that went from his hives. Almost immediately a bee alighted upon a twig, and soon with its mandibles opened a bud, and drew from it a thread of the viscid matter which it contained; with one of its second pair of legs it took it from the mouth, and placed it in the basket: thus it proceeded till it had given them both their load[b]. I have myself seen bees very busy collecting it from the Tacamahaca (*Populus balsamifera*, L.). But this is an old discovery, confirmed by recent observation; for Mouffet tells us from Cordus, that it is collected from the gems of trees, instancing the poplar and the birch[c]. Riem observes that it is

[a] Compare Reaum. 420, and Huber, ii. 24, with Wildman, 40.
[b] Huber, ii. 260. [c] *Insect. Theatr.* 36. Schirach, 241.

also collected from the pine and fir. The propolis is soft, red, will pull out in a thread, is aromatic, and imparts a gold colour to white polished metals. It is employed in the hive not only in finishing the combs, as I related in my letter on Habitations[a]; but also in stopping every chink or orifice by which cold, wet, or any enemy, can enter. They cover likewise with it the sticks which support the combs, and often spread it over a considerable portion of the interior of the hive. Like the pellets of pollen, it is carried on the posterior tibiæ, but the masses are lenticular[b].

Mr. Knight mentions an instance of bees using an artificial kind of propolis. He had caused the decorticated part of some tree to be covered with a cement composed of bees-wax and turpentine: finding this to their purpose, they attacked it, detaching it from the tree by their mandibles, and then, as usual, passing it from the first leg to the second, and so to the third. When one bee had thus collected its load, another often came behind and despoiled it of all it had collected; a second and third load were frequently lost in the same manner; and yet the patient animal pursued its labours without showing any signs of anger[c].

Bees in their excursions do not confine themselves to the spot immediately contiguous to their dwelling, but, when led by the scent of honey, will go a mile from it. Huber even assigns to them a radius of half a league round their hive for their ordinary excursions; yet from this distance they will discover honey with as much cer-

[a] Vol. I. 4th Ed. 500. [b] Reaum. *ubi supr.* 437—
[c] *Philos. Trans.* 1807, 242.

tainty as if it was within their sight. To prove that it is by their scent that bees find it out, he put some behind a window-shutter, in a place where it could not be seen, leaving the shutter just open enough for insects, if they liked, to get at it. In less than a quarter of an hour four bees, a butterfly, and some house-flies had discovered it. At another time he put some into boxes, with little apertures in the lid, into which pieces of card were fitted, which he placed about two hundred paces from his hives. In about half an hour the bees discovered them, and traversing them very industriously, soon found the apertures, when, pushing in the pieces of card, they got to the honey. That contained in the blossom of many plants is quite as much concealed, yet the acuteness of their scent enables them to detect it.

These insects, especially when laden and returning to their nest, fly in a direct line, which saves both time and labour. How they are enabled to do this with such certainty as to make for their own abode without deviation, I must leave to others to explain. Connected with this circumstance, and the acuteness of their smell, is the following curious account, given in the *Philosophical Transactions* for 1721, of the method practised in New England for discovering where the wild hive-bees live in the woods, in order to get their honey. The honey-hunters set a plate containing honey or sugar upon the ground in a clear day. The bees soon discover and attack it: having secured two or three that have filled themselves, the hunter lets one go, which rising into the air, flies straight to the nest: he then strikes off at right angles with its course a few hundred yards, and letting a

second fly, observes its course by his pocket-compass, and the point where the two courses intersect is that where the nest is situated[a].

The natural station of bees is in the cavities of decayed trees; such trees, Mr. Knight tells us, they will discover in the closest recesses, and at an extraordinary distance from the hive; in one instance it was a mile: and at swarming, they sometimes are inclined to settle in such cavities. After the discovery of one, from twenty to fifty, who are a kind of scouts, may be found examining and keeping possession of it. They seem to explore every part of it and of the tree with the greatest attention, even surveying the dead knots and the like[b]. When a hive stands unemployed, a swarm will also sometimes send scouts to take possession of it.

How long our little active creatures repose before they take a second excursion I cannot precisely say. In a hive the greatest part of the inhabitants generally appear in repose, lying together, says Reaumur, but this probably for a short time. Huber tells us, that bees may always be observed in a hive with the head and thorax inserted into cells that contain eggs, and sometimes into empty ones: and that they remain in this situation fifteen or twenty minutes so motionless, that did not the dilatation of the segments of the abdomen prove the contrary, they might be mistaken for dead. He supposes their object is repose from their labours[c]. The queen,

[a] xxxi. 148.

[b] Knight in *Philos. Trans.* for 1807, 237. Marshall, *Agricult. of Norfolk.*

[c] It has been supposed, and the supposition was adopted originally in this work (Vol. I. 1st Ed. p. 371), that the object in this case is brooding the eggs; but upon further consideration we incline to

for this purpose, enters the large cells of the males, and continues in them without motion a very long time. Even then the workers form a circle round her, and brush the uncovered part of her abdomen. The drones while reposing do not enter the cells, but cluster in the combs, and sometimes remain without stirring a limb for eighteen or twenty hours[a].

Reaumur observes, that in a hive the population of which amounts to 18,000, the number that enter the hive in a minute is a hundred; which, allowing fourteen hours in the day for their labour, makes 84,000: thus every individual must make four excursions daily, and some five. In hives where the population was smaller, the numbers that entered were comparatively greater, so as to give six excursions or more to each bee[b]. But in this calculation Reaumur does not seem to take into the account those that are employed within the hive in building or feeding the young brood; which must render the excursions of each bee still more numerous. He proceeds further to ground upon this statement a calculation of the quantity of bee-bread that may be collected in one day by such a hive; and he found, supposing

Huber's opinion. that it has no connexion with it, the ordinary temperature of the hive being sufficient for this purpose; and the circumstance of their entering unoccupied cells proves that this attitude has no particular connexion with the eggs. *Huber*, i. 212.—"When large pieces of comb," says Wildman (p. 45), "were broken off and left at the bottom of the hive, a great number of bees have gone and placed themselves upon them." This looks like incubation. Reaumur however affirms (p. 591) that if part of a comb falls and loses its perpendicular direction, the bees, as if conscious that they would come to nothing, pull out and destroy all the larvæ. They might perhaps remain perpendicular in the case observed by Wildman.

[a] Reaum. v. 431. Huber, ii. 212. [b] Reaum. v. 432—

only half the number to collect it, that it would amount to more than a pound; so that in one season, one such hive might collect a hundred pounds[a]. What a wonderful idea does this give of the industry and activity of these little useful creatures! And what a lesson do they read to the members of societies that have both reason and religion to guide their exertions for the common good! Adorable is that Great Being who has gifted them with instincts, which render them as instructive to us, if we will condescend to listen to them, as they are profitable.

While I am upon this part of the story of bees, I cannot pass over the account Reaumur has given from Maillet of the transportation of hives in Egypt from one place to another, before alluded to[b], to enable them to make in greater abundance their collections of honey, &c. Towards the end of October, when the inundations of the Nile have ceased, and the husbandmen can sow their land, saintfoin is one of the first things that is sown; and as Upper Egypt is warmer than the Lower, the saintfoin gets there first into blossom. At this time, bee-hives are transported in boats from all parts of Egypt into the upper district, and are there heaped in pyramids upon the boats prepared to receive them; each being numbered by the individual to which it belongs. In this station they remain some days; and when they are judged to have got in the harvest of honey and pollen that is to be collected there, they are removed two or three leagues lower down, where they remain the same time; and so they proceed till towards the middle of Fe-

[a] Reaum. v. 434— [b] Vol. I. 4th Ed. 331. Reaumur, v. 698—

bruary, when having traversed Egypt, they arrive at the sea, from whence they are dispersed to their several owners.

John Hunter observes, that when the season for laying is over, that for collecting honey comes on (he means, probably, for making the principal collection of it); and that when the last pupa is disclosed, the cell it deserts, after being cleaned, is immediately filled with it; and as soon as full is covered with pure wax: but this only holds with respect to the cells containing honey for winter use, those destined to receive that which forms their food when bad weather prevents them from going out, being left open[a]. Sometimes, when the year is remarkably favourable for collecting honey, the bees will destroy many of the larvæ to make room for it; but they never meddle with the pupæ. When no more honey is to be collected, they remain quiet in the hive for the winter. Mr. Hunter found that a hive grew lighter in a cold than in a warm week; he found also, that in three months (from November 10th to February 9th) a single hive lost 72 oz. 1½ dram[b].

Water is a thing of the first necessity to these insects; but they are not very delicate as to its quality, but rather the reverse; often preferring what is stagnant and putrescent, to that of a running stream[c]. I have frequently observed them busy in corners moist with urine; perhaps this is for the sake of the saline particles to be there collected.

A new-born bee, as soon as it is able to use its wings,

[a] *Philos. Trans.* 1792, 160. Comp. Reaum. v. 450.
[b] Reaum. *ibid.* 591— Hunter, *ibid.* 161— [c] Reaum. *ibid.* 697.

seems perfectly aware, without any previous instruction, what are to be its duties and employments for the rest of its life. It appears to know that it is born for society, and not for selfish pursuits; and therefore it invariably devotes itself and its labours to the benefit of the community to which it belongs. Walking upon the combs, it seeks for the door of the hive, that it may sally forth and be useful. Full of life and activity, it then takes its first flight; and, unconducted but by its instinct, visits like the rest the subjects of Flora, absorbs their nectar, covers itself with their ambrosial dust, which it kneads into a mass and packs upon its hind legs; and if need be, gathers propolis, and returns unembarrassed to its own hive[a].

Instances of the expedition with which our little favourites accomplish their various objects you have had several; but this is never more remarkable than when they settle in a new hive. At this time, in twenty-four hours they will sometimes construct a comb twenty inches long by seven or eight wide; and the hive will be half filled in five or six days; so that in the first fifteen days as much wax is made as in the whole year besides[b].

In treating of the various employments of the bees, I must not omit one of the greatest importance to them—the *ventilation* of their abode. When you consider the numbers contained in so confined a space; the high temperature to which its atmosphere is raised; and the small aperture at which the air principally enters, you will readily conceive how soon it must be rendered unfit

[a] Reaum. v. 602. [b] Ibid. 656.

for respiration, and be convinced that there must be some means of constantly renewing it. If you feel disposed to think that the ventilation takes place, as in our apartments, by natural means, resulting from the rarefaction of the air by the heat of the hive, and the consequent establishment of an interior and exterior current—a simple experiment will satisfy you that this cannot be. Take a vessel of the size of a bee-hive, with a similar or even somewhat larger aperture—introduce a lighted taper, and if the temperature be raised to more than 140°, it will go out in a short time. We must therefore admit, as Huber observes[a], that the bees possess the astonishing faculty of attracting the external air, and at the same time of expelling that which has become corrupted by their respiration.

What would you say, should I tell you that the bees upon this occasion have recourse to the same instrument which ladies use to cool themselves when an apartment is overheated? Yet it is strictly the case. By means of their marginal hooks, they unite each pair of wings into one plane slightly concave, thus acting upon the air by a surface nearly as large as possible, and forming for them a pair of very ample fans, which in their vibrations describe an arch of 90°. These vibrations are so rapid as to render the wings almost invisible. When they are engaged in ventilation, the bees by means of their feet and claws fix themselves as firmly as possible to the place they stand upon. The first pair of legs is stretched out before; the second extended to the right and left; whilst the third, placed very near

[a] ii. 339.

each other, are perpendicular to the abdomen, so as to give that part considerable elevation.

Maraldi, and after him Reaumur, long ago noticed this action of the bees; but they attributed to it an effect the reverse of that which it really produces; the former imagining it to occasion directly the high temperature of the hive, and the latter indirectly[a]. It was reserved for Huber to discover the true cause of it; and from him the chief of what I have to say upon the subject will be derived[b].

During the summer a certain number of workers—for it is to the workers solely that this office is committed—may always be observed vibrating their wings before the entrance of their hive; and the observant apiarist will find upon examination, that a still greater number are engaged within it in the same employment. All those thus circumstanced that stand without, turn their head to the entrance; while those that stand within, turn their back to it. The station of these ventilators is upon the floor of the hive. They are usually ranged in files, that terminate at the entrance; and sometimes, but not constantly, form so many diverging rays, probably to give room for comers and goers to pass. The number of ventilators in action at the same time varies: it seldom much exceeds twenty, and is often more circumscribed. The time also that they devote to this function is longer or shorter according to circumstances: some have been observed to continue their vibrations for nearly half an hour without resting, suspending the action for not more than an instant, as it should seem to take breath. When

[a] Reaum. v. 672. [b] Huber, ii. 338—362.

one retires, another occupies its place; so that in a hive well peopled there is never any interruption of the sound or humming occasioned by this action; by which it may always be known whether it be going on or not.

This humming is observable not only during the heats of summer, but at all seasons of the year. It sometimes seems even more forcible in the depth of winter than when the temperature of the atmosphere is higher. An employment so constant, which always occupies a certain number of bees, must produce as constant an effect. The column of air once disturbed within, must give place to that without the hive; thus a current being established, the ventilation will be perpetual and complete.

To be convinced that such an effect is produced, approach your hand to a ventilating bee, and you will find that she causes a very perceptible motion in the air. Huber tried an experiment still more satisfactory. On a calm day, at the time when the bees had returned to their habitation—having fixed a screen before the mouth of the hive to prevent his being misled by any sudden motion of the external air—he placed within the screen little anemometers or wind-gauges, made of bits of paper, feather, or cotton, suspended by a thread to a crotch. No sooner did they enter the atmosphere of the bees than they were put in motion, being alternately attracted and repelled to and from the aperture of the hive with considerable rapidity. These attractions and repulsions were proportioned to the number of bees engaged in ventilation, and, though sometimes less perceptible, were never entirely suspended. Burnens tried a similar experiment in the winter, when the thermometer stood in

the shade at 33°. Having selected a well-peopled hive, the inhabitants of which appeared full of life and sufficiently active in the interior, and luted it all around, except the aperture to the platform on which it stood, he stuck in the top a piece of iron wire which terminated in a hook, to which he fastened a hair with a small square of very thin paper at the other end; this was exactly opposite to the aperture, at the distance of about an inch from it. As soon as the apparatus was fixed, the hair with its paper pendulum began to oscillate more or less, the greatest oscillations on both sides being an inch, by admeasurement, from the perpendicular: if the paper was moved by force to a greater distance, the vibrations did not take place, and the apparatus remained at rest. He then made an opening in the top of the hive, and poured in some liquid honey: soon after there arose a hum, the movement in the interior increased, and some bees came out. The oscillations of the pendulum upon this became more frequent and intense, and extended to fifteen lines or an inch and a quarter from the perpendicular; but when the paper was removed to a greater distance from the aperture, it remained at rest.

Huber, at the proposal of M. de Saussure, in order to ascertain whether artificial ventilators would produce an analogous effect, got a mechanical friend to construct for him a little mill with eighteen sails of tin. He also prepared a large cylindrical vase, into which he could, at an aperture in the box upon which it was fixed, introduce a lighted taper. In one side of this box was another aperture to represent that of a hive, but larger. The ventilator was placed below, and luted at the points of contact, and anemometers were suspended before the

aperture. The first experiment was the introduction of the taper, without putting the ventilator in motion. Though the capacity of the vessel was about 3228 cubic inches, the flame soon diminished, and went out in about eight minutes, and the anemometers continued motionless. The same experiment was next repeated with the door shut, with precisely the same result. After the air of the vessel had been renewed, the taper was again introduced, and the ventilator set in motion: immediately, as appeared by the oscillations of the anemometers, two currents of air were established, and the brilliancy of the flame was not diminished during the whole course of the experiment, which might have been prolonged for an indefinite time. A thermometer placed in the lower part of the apparatus rose to 112°; and the temperature was evidently still more elevated at the top of the receiver.

The Creator often has one end in view in the actions of animals, (and nothing more conspicuously displays the invisible hand that governs the universe,) while the agents themselves have another. This probably is the case in the present instance, since we can scarcely suppose that the bees beat the air with their wings in order to ventilate the hive, but rather to relieve themselves from some disagreeable sensation which oppresses them. The following experiments prove that one of their objects in this action, as it is with ladies when they use their fans, is to cool themselves when they suffer from too great heat. When Huber once opened the shutter of a glazed hive, so that the solar rays darted upon the combs covered with bees, a humming, the sign of ventilation, soon was heard amongst them, while those which were in the shade remained tranquil. The bees composing the clusters

which often are suspended from the hives in summer, when they are incommoded by the heat of the sun, fan themselves with great energy. But if by any means a shadow is cast over any portion of the group, the ventilation ceases there, while it continues in the part which feels the heat of the sun. The same cause produces a similar effect upon humble-bees, wasps, and hornets.

Amongst the bees, however, it is remarkable that ventilation goes on even in the depth of winter, when it cannot be occasioned by excess of heat.—This therefore can only be regarded as a secondary cause of the phenomenon. From other experiments, which, having already detained you too long, I shall not here detail, it appears that penetrating and disagreeable odours produce the same effect[a]. Perhaps, though Huber does not say this, the odour produced by the congregated myriads of the hive may be amongst the principal motives that impel its inhabitants to this necessary action.

Whatever be the proximate cause, it is I trust now evident to you, that the Author of nature, having assigned to these insects a habitation into which the air cannot easily penetrate, has gifted them with the means of preventing the fatal effects which would result from corrupted air. An indirect effect of ventilation is the elevated temperature which these animals maintain, without any effort, in their hive:—but upon this I shall enlarge hereafter.

Bees are extremely neat in their persons and habitations, and remove all nuisances with great assiduity, at least as far as their powers enable them. Sometimes

[a] Huber, ii. 359—

slugs or snails will creep into a hive, which with all their address they cannot readily expel or carry out. But here their instinct is at no loss; for they kill them, and afterwards embalm them with propolis, so as to prevent any offensive odours from incommoding them. An unhappy snail, that had travelled up the sides of a glazed hive, and which they could not come at with their stings, they fixed, a monument of their vengeance and dexterity, by laying this substance all around the mouth of its shell[a]. When they expel their excrements, they go apart that they may not defile their companions: and in winter, when prevented by extreme cold, or the injudicious practice of wholly closing the door of the hive, from going out for this purpose, their bodies sometimes become so swelled from the accumulation of feces in the intestines, that when at last able to get out they can no longer fly, so that falling to the ground in the attempt, they perish with cold, the sacrifice of personal neatness[b]. When a bee is disclosed from the pupa and has left its cell, a worker comes, and taking out its envelope carries it from the hive; another removes the exuviæ of the larva, and a third any filth or ordure that may remain, or any pieces of wax that may have fallen in when the nascent imago broke from its confinement. But they never attempt to remove the internal lining of silk that covers the walls, spun by the larva previous to its metamorphosis, because, instead of being a nuisance, it renders the cell more solid[c].

Having now described to you the usual employments of my little favourites both within doors and without, I

[a] Reaum. v. 442. [b] Bonner *On Bees*, 102.
[c] Reaum. *ubi supr.* 580-600.

shall next enlarge a little upon their language, memory, tempers, manners, and some other parts of their history.

"Brutes" (it is the remark of Mr. Knight) "have language to express sentiments of love, of fear, of anger; but they seem unable to transmit any impression they have received from external objects. But the language of bees is more extensive; if not a language of ideas, it is something very similar[a]." You have seen above that the organ of the language of ants is their antennæ. Huber has proved satisfactorily, that these parts have the same use with the bees. He wished to ascertain whether, when they had lost a queen (intelligence which traverses a whole hive in about an hour) they discovered the sad event by their smell, their touch, or any unknown cause. He first divided a hive by a grate, which kept the two portions about three or four lines apart; so that they could not come at each other, though scent would pass. In that part in which there was no queen, the bees were soon in great agitation; and as they did not discover her where she was confined, in a short time they began to construct royal cells, which quieted them. He next separated them by a partition through which they could pass their antennæ, but not their heads. In this case the bees all remained tranquil, neither intermitting the care of the brood, nor abandoning their other employments; nor did they begin any royal cell. The means they used to assure themselves that their queen was in their vicinity and to communicate with her, was to pass their antennæ through the openings of the grate. An infinite number of these organs might be seen at once, as it were,

[a] In *Philos. Trans.* 1807, 239.

inquiring in all directions; and the queen was observed answering these anxious inquiries of her subjects in the most marked manner; for she was always fastened by her feet to the grate, crossing her antennæ with those of the inquirers. Various other experiments, which are too long to relate, prove the importance of these organs as the instrument of communicating with each other, as well as to direct the bee in all its proceedings[a]. Besides their antennæ, the bees also cause themselves to be understood by certain sounds, not indeed produced by the mouth, but by other parts of their body:—but upon this subject I shall have occasion to enlarge hereafter.

That bees can remember agreeable sensations at least, is evident from the following anecdote related by Huber. —One autumn some honey was placed upon a window —the bees attended it in crowds. The honey was taken away, and the window closed with a shutter all the winter. In the spring, when it was re-opened, the bees returned, though no fresh honey had been placed there[b].

From the earliest times our little citizens of the hive have had the character of being an irritable race. Their anger is without bounds, says Virgil; and if they are molested, this character is no exaggeration. Some individuals, however, they will suffer to go near their hives, and to do almost any thing: and there are others to whom they seem to take such an antipathy, that they will attack them unprovoked. A great deal will probably depend upon this—whether any thing has happened to put them out of humour. The bees usually do not attack me; but I remember one day last year, when the

[a] Huber, ii. 407— [b] Ibid. 375.

asparagus was in blossom, which a large number were attending, I happened to go between my asparagus beds; which discomposed them so much, that I was obliged to retreat with hasty steps, and some of them flew after me; I escaped however unstung. Thorley relates an anecdote of a gentleman, who, desirous of securing a swarm of bees that had settled in a hollow tree, rashly undertook to dislodge them. He succeeded; but though he had used the precaution of securing his head and hands, he was so stung by the furious animals, that a violent fever was the consequence, and his recovery was for some time doubtful. The strength of his constitution at length prevailed; and the hole of the tree being stopped, the survivors of the battle settled upon a branch, were hived, and became the dear-bought property of their conqueror [a].

In Mungo Park's last mission to Africa, he was much annoyed by the attack of bees, probably of the same tribe with our hive-bee. His people, in search of honey, disturbed a large colony of them. The bees sallied forth by myriads, and attacking men and beasts indiscriminately, put them all to the rout. One horse and six asses were either killed or missing in consequence of their attack; and for half an hour the bees seemed to have completely put an end to their journey. Isaaco upon another occasion lost one of his asses, and one of his men was almost killed by them [b].

Bees, however, if they are not molested, are not usually ill-tempered: if you make a captive of their queen, they

[a] Thorley, 16 — The Psalmist alludes to the fury of these creatures, when he says of his enemies, "They compassed me about like bees." *Ps.* cxviii. 12.

[b] Park's *Last Mission*, 153. 297. Comp. *Journal*, 331.

will cluster upon your head, or any other part of your body, and never attempt to sting you. I remember, when a boy, seeing the celebrated Wildman exhibit many feats of this kind, to the great astonishment and apprehension of the uninformed spectators. The writer lately quoted (Thorley) was assisted once by his maid-servant to hive a swarm. Being rather afraid, she put a linen cloth as a defence over her head and shoulders. When the bees were shaken from the tree on which they had alighted, the queen probably settled upon this cloth; for the whole swarm covered it, and then getting under it, spread themselves over her face, neck, and bosom, so that when the cloth was removed she was quite a spectacle. She was with great difficulty kept from running off with all the bees upon her; but at length her master quieted her fears, and began to search for the queen. He succeeded; and hoped when he put her into the hive that the bees would follow; but they only seemed to cluster more closely. Upon a second search he found another queen, (unless the same had escaped and returned,) whom seizing, he placed in the hive. The bees soon missed her, and crowded after her into it: so that in the space of two or three minutes not one was left upon the poor terrified girl. After this escape, she became quite a heroine, and would undertake the most hazardous employments about the hives[a].

Many means have been had recourse to for the dispersion of mobs and the allaying of popular tumults. In St. Petersburgh (so travellers say) a fire-engine playing upon them does not always cool their choler; but were a few hives of bees thus employed, their discomfiture would be

[a] Thorley, 150—

certain. The experiment has been tried. Lesser tells us, that in 1525, during the confusion occasioned by a time of war, a mob of peasants assembling in Hohnstein (in Thuringia) attempted to pillage the house of the minister of Elende; who having in vain employed all his eloquence to dissuade them from their design, ordered his domestics to fetch his bee-hives, and throw them in the middle of this furious mob. The effect was what might be expected; they were immediately put to flight, and happy if they escaped unstung[a].

The anger of bees is not confined to man; it is not seldom excited against their own species. From what I have said above respecting the black bees[b] and their fate, it seems not improbable that, when the workers become too old to be useful to the community, they are either killed, or expelled the society. Reaumur, who observed that the inhabitants of the same hive had often mortal combats, was of opinion that this was their object in these battles[c], which take place, he observes, in fine or warm weather. On these occasions the bees are sometimes so eager, that examining them with a lens does not part them:—their whole object is to pierce each other with their sting, the stroke of which, if once it penetrates to the muscles, is mortal. In these engagements the conqueror is not always able to extricate this weapon, and then both perish. The duration of the conflict is uncertain; sometimes it lasts an hour, and at others is very soon determined: and occasionally it happens that both parties, fatigued and despairing of victory, give up the contest and fly away.

But the wars of bees are not confined to single combats;

[a] Lesser, *L.* ii. 171. [b] See above, p. 128. [c] Reaum. v. 360-365.

general actions now and then take place between two swarms. This happens when one takes a fancy to a hive that another has pre-occupied. In fine warm weather, strangers, that wish to be received amongst them, meet with but an indifferent welcome, and a bloody battle is the consequence. Reaumur witnessed one that lasted a whole afternoon, in which many victims fell. In this case the battle is still between individuals, who at one time decide the business within the hive, and at another at some distance without. In the former case the victorious bee flies away, bearing her victim under her body between her legs, sometimes taking a longer and sometimes a shorter flight before she deposits it upon the ground.—She then takes her repose near the dead body, standing upon her four anterior legs, and rubbing the two hinder ones against each other. If the battle is not concluded within the hive, the enemy is carried to a little distance, and then dispatched.

This strange fury however does not always show itself on this occasion; for now and then some friendly intercourse seems to take place. Bees, from a hive in Mr. Knight's garden, visited those in that of a cottager, a hundred yards distant, considerably later than their usual time of labour, every bee as it arrived appearing to be questioned. On the tenth morning, however, the intercourse ceased, ending in a furious battle. On another occasion, an intimacy took place between two hives of his own, at twice the distance, which ceased on the fifth day. Sometimes he observed that this communication terminated in the union of two swarms; as in one instance, where a swarm had taken possession of a hollow tree[a], it

[a] *Philos. Trans.* 1807, 234—

is probable that the reception of one swarm by another may depend upon their numbers, and the fitness of their station to accommodate them. Thorley witnessed a battle of more than two days continuance, occasioned by a strange swarm forcing their way into a hive[a]. Two swarms that rise at the same time sometimes fight till great numbers have been destroyed, or one of the queens slain, when both sides cease all their enmity and unite under the survivor[b].

These apiarian battles are often fought in defence of the property of the hive. Bees that are ill managed, and not properly fed, instead of collecting for themselves, will now and then get a habit of pillaging from their more industrious neighbours: these are called by Schirach *corsair* bees, and by English writers, *robbers*. They make their attack chiefly in the latter end of July, and during the month of August. At first they act with caution, endeavouring to enter by stealth; and then, emboldened by success, come in a body. If one of the queens be killed, the attacked bees unite with the assailants, take up their abode with them, and assist in plundering their late habitation[c]. Schirach very gravely recommends it to apiarists whose hives are attacked by these depredators, to give the bees some honey mixed with brandy or wine, to increase and inflame their courage, that they may more resolutely defend their property against their piratical assailants[d]. It is however to be apprehended, that this method of making them pot-valiant might induce them to attack their neighbours, as well as to defend themselves.

Sometimes combats take place in which three or four

[a] 166. [b] Thorley, *ibid.* Comp. Mills *On Bees,* 63.
[c] Comp. Schirach, 49. Mills, 62— Thorley, 163— [d] 51.

bees attack a single individual, not with a design to kill, but merely to rob: one seizes it by one leg, another by another; till perhaps there are two on each side, each having hold of a leg, or they bite its head or thorax. But as soon as the poor animal that is thus haled about and maltreated unfolds its tongue, one of the assailants goes and sucks it with its own, and is followed by the rest, who then let it go. These insects, however, in their ordinary labours are very kind and helpful to each other; I have often seen two, at the same moment, visit the same flower, and very peaceably despoil it of its treasures, without any contention for the best share.

As the poison of bees exhales a penetrating odour, M. Huber was curious to observe the effect it might produce upon them. Having extracted with pincers the sting of a bee and its appendages impregnated with poison, he presented it to some workers, which were settled very tranquilly before the gate of their mansion. Instantaneously the little party was alarmed; none however took flight, but two or three darted upon the poisoned instrument, and one angrily attacked the observer. When however the poison was coagulated, they were not in the least affected by it—A tube impregnated with the odour of poison recently ejected being presented to them, affected them in the same manner[a]. This circumstance may sometimes occasion battles amongst them, that are not otherwise easy to be accounted for.

Anger is no useless or hurtful passion in bees: it is necessary to them for the preservation of themselves and their property, which, besides those of their own species, are exposed to the ravages of numerous enemies. Of

[a] ii. 380—

these I have already enumerated several of the class of insects, and also some beasts and birds that have a taste for bees and their produce[a]. The *Merops Apiaster* (which has been taken in England), the lark and other birds catch them as they fly. Even the frog and the toad are said to kill great numbers of bees; and many that fall into the water probably become the prey of fish. The mouse also, especially the field-mouse, in winter often commits great ravages in a hive, if the base and orifices are not well secured and stopped[b]. Thorley once lost a stock by mice, which made a nest and produced young amongst the combs[c]. The titmouse, according to the same author, will make a noise at the door of the hive, and when a bee comes out to see what is the matter, will seize and devour it. He has known them eat a dozen at a time. The swallows will assemble round the hives and devour them like grains of corn[d]. I need only mention spiders, in whose webs they sometimes meet with their end, and earwigs and ants, which creep into the hive and steal the honey[e].

Upon this subject of the enemies of bees, I cannot persuade myself to omit the account Mr. White has given of an idiot-boy, who from a child showed a strong propensity to bees. They were his food, his amusement, his sole object. In the winter he dozed away his time in his father's house, by the fire-side, in a torpid state, seldom leaving the chimney-corner: but in summer he was all alert and in quest of his game. Hive-bees, humble-bees, and wasps were his prey wherever he found them. He had no apprehension from their stings, but

[a] Vol. I. 4th Ed. 164, and 280. 288. [b] Schirach, 52.
[c] 170. [d] Reaum. v. 710. [e] Thorley, 171.

would seize them with naked hands, and at once disarm them of their weapons, and suck their bodies for the sake of their honey-bags. Sometimes he would fill his bosom between his shirt and skin with these animals; and sometimes he endeavoured to confine them in bottles. He was very injurious to men that kept bees; for he would glide into their bee-gardens, and sitting down before the stools, would rap with his fingers, and so take the bees as they came out. He has even been known to overturn the hives for the sake of the honey, of which he was passionately fond. Where metheglin was making, he would linger round the tubs and vessels, begging a draught of what he called *bee-wine*. As he ran about, he used to make a humming noise with his lips resembling the buzzing of bees. This lad was lean and sallow, and of a cadaverous complexion; and except in his favourite pursuit, in which he was wonderfully adroit, discovered no manner of understanding. Had his capacity been better, and directed to the same object, he had perhaps abated much of our wonder at the feats of a more modern exhibiter of bees; and we may justly say of him now,

> " . . . . Thou,
> Had thy presiding star propitious shone,
> Should'st Wildman be."[a]

The worker bees are annual insects, though the queen will sometimes live more than two years; but, as every swarm consists of old and young, this is no argument for burning them. It is a saying of bee-keepers in Holland, that the first swallow and the first bee foretell each

[a] White's *Nat. Hist.* 8vo. i. 339—

other[a]. This perhaps may be correct there; but with us the appearance of bees considerably precedes that of the swallow; for when the early crocuses open, if the weather be warm, they may always be found busy in the blossom.

The time that bees will inhabit the same stations is wonderful. Reaumur mentions a countryman who preserved bees in the same hive for thirty years[b]. Thorley tells us that a swarm took possession of a spot under the leads of the study of Ludovicus Vives in Oxford, where they continued a hundred and ten years, from 1520 to 1630[c]. These circumstances have led authors to ascribe to bees a greater age than they can claim. Thus Mouffet, because he knew a bees-nest which had remained thirty years in the same quarters, concludes that they are very long-lived, and very sapiently doubts whether they even die of old age at all[d]!!! Which is just as wise as if a man should contend, because London had existed from before the time of Julius Cæsar, that therefore its inhabitants must be immortal.

Bees are subject to many accidents, particularly, as I have said above, they often fall or are precipitated by the wind into water; and though like the cat a bee has not nine lives, nor

> "Nine times emerging from the crystal flood,
> She mews to every watery god,"

yet she will bear submersion nine hours; and, if exposed to sufficient heat, be reanimated. In this case their proboscis is generally unfolded, and stretched to its full

[a] Swamm. *Bib. Nat.* Ed. Hill, i. 160. [b] *ubi supr.* 665.
[c] 178— [d] *Theatr. Ins.* 21.

length. At the extremity of this, motion is first perceived, and then at the ends of the legs. After these symptoms appear they soon recover, fold up the tongue, and plume themselves for flight[a]. Experimentalists may therefore, without danger, submerge a hive of bees, when they want to examine them particularly, for they will all revive upon being set to the fire. Reaumur says that in winter, during frosts, the bees remain in a torpid state. He must mean severe frosts; for Huber relates an instance, when upon a sudden emergency, the bees of one of his hives set themselves to work in the middle of January; and he observes that they are so little torpid in winter, that even when the thermometer abroad is below the freezing point, it stands high in populous hives. Swammerdam, and after him the two authors last quoted, found that sometimes, even in the middle of winter, hives have young brood in them, which the bees feed and attend to[b]. In an instance of this kind, which fell under the eye of Huber, the thermometer stood in the hive at about 92°. In colder climates, however, the bees will probably be less active in the winter. They are then generally situated between the combs towards their lower part. But when the air grows milder, especially if the rays of the sun fall upon the hive and warm it, they awake from their lethargy, shake their wings, and begin to move and recover their activity; with which their wants returning, they then feed upon the stock of honey and bee-bread

[a] Reaum. v. 540—

[b] January 11, 1818. My bees were out, and very alert this day. The thermometer stood abroad in the shade at 51½°. When the sun shone there was quite a cluster of them at the mouth of the hives, and great numbers were buzzing about in the air before them.

which they have in reserve. The lowest cells are first uncovered, and their contents consumed; the highest are reserved to the last. The honey in the lowest cells being collected in the autumn, probably will not keep so well as the vernal.

The degree of heat in a hive in winter, as I have just hinted, is great. A thermometer near one, in the open air, that stood in January at $6\frac{3}{4}$° below the freezing point, upon the insertion of the bulb a little way into the hive, rose to $22\frac{1}{2}$° above it; and could it have been placed between the combs, where the bees themselves were agglomerated, the mercury, Reaumur conjectures, would have risen as high as it does abroad in the warm days in summer[a]. Huber says that it stands in frost at 86° and 88° in populous hives[b]. In May, the former author found, in a hive in which he had lodged a small swarm, that the thermometer indicated a degree of heat above that of the hottest days of summer[c]. He observes that their motion, and even the agitation of their wings, increases the heat of their atmosphere. Often, when the squares of glass in a hive appeared cold to the touch, if either by design or chance he happened to disturb the bees, and the agglomerated mass in a tumult began to move different ways, sending forth a great hum, in a very short time so considerable an accession of heat was produced, that when he touched the same squares of glass, he felt them as hot as if they had been held near a fierce fire. By teasing the bees, the heat generated was sometimes so great as to soften very much the wax of the combs, and even to cause them to fall[d]. This generation of heat in bee-hives

[a] v. 671. [b] i. 354. Note *. [c] *ubi supr.* [d] Reaum. v. 672.

seems to be one of those mysteries of nature that has not yet been satisfactorily accounted for. Generally speaking, insects appear to have no animal heat; the temperature of their bodies being usually that of the atmosphere in which they happen to be. But bees are an exception to this rule, and produce heat in themselves. Whether they are the only insect that can do this, as John Hunter affirms, or whether others that are gregarious, such as humble-bees, wasps, and ants, may not possess the same faculty, seems not yet clearly ascertained. The heat in the hive in the above instance was evidently occasioned by the tumult into which the bees were put; and the hum, and motions that followed it, were probably the result of their anger. But how these act physically, in an animal that has no circulation, I am unable to say; and must leave the question, like my predecessors, undecided.

And now, having detailed to you thus amply the wonderful history and proceedings of the social tribes of the insect world, you will allow, I think, that I have redeemed my pledge, when I taught you to expect that this history would exceed in interest and variety and marvellous results every thing that I had before related to you. I trust, moreover, that you will scarcely feel disposed to subscribe to that opinion, though it has the sanction of some great names, which attributes these almost miraculous instincts to mere sensation; which tells us, that the sensorium of these insects is so modelled with respect to the different operations that are given them in charge, that it is by the attraction of pleasure alone that they are determined to the execution of them; and that, as every

circumstance relative to the succession of their different labours is pre-ordained, to each of them an agreeable sensation is affixed by the Creator: and that thus, when the bees build their cells; when they sedulously attend to the young brood; when they collect provisions; this is the result of no plans, of no affection, of no foresight; but that the sole determining motive is the enjoyment of an agreeable sensation attached to each of these operations[a]. Surely it would be better to resolve all their proceedings at once into a direct impulse from the Creator, than to maintain a theory so contrary to fact; and which militates against the whole history which M. Huber, who adopts this theory from Bonnet, has so ably given of these creatures. That they may experience agreeable sensations from their various employments, nobody will deny; but that such sensations instruct them how to perform their several operations, without any plan previously impressed upon their sensorium, is contrary both to reason and experience. They have a plan, it is evident; and that plan, which proves that it is not mere sensation, they vary according to circumstances. As to affection—that bees are irritable, and feel the passion of anger, no one will deny; that they are also susceptible of fear, is equally evident: and if they feel anger and fear, why may they not also feel *love?* Further, if they have recourse to precautions for the prevention of any evil that seems to threaten them, how can we refuse them a degree of *foresight?* Must we also resolve all their patriotism, and the singular regard for the welfare of their community, which

[a] Huber, i. 313.

seems constantly to actuate them, and the sacrifices, even sometimes of themselves, that they make to promote and ensure it, into individual self-love? We would not set them up as rivals to man in intelligence, foresight, and the affections; but they have that degree of each that is necessary for their purposes. On account of the difficulties attending all theories that give them some degree of these qualities, to resolve all into mere sensation, is removing one difficulty by a greater.

That these creatures from mere selfishness build their combs, replenish them with the fruit of their unwearied labours, attend so assiduously to the nurture of the young brood, lavish their caresses upon their queen, prevent all her wants, give a portion of the honey they have collected to those that remain in the hives, assist each other, defend their common dwelling, and are ready to sacrifice themselves for the public good—is an anomaly *in rerum natura* that ought never to be admitted, unless established by the most irrefragable demonstration;—and I think you will not be disposed without full proof to yield yourself to a mere theory, so contradictory of all the facts we know relative to this subject.

After all, there are mysteries, as to the *primum mobile*, amongst these social tribes, that with all our boasted reason we cannot fathom; nor develop satisfactorily the motives that urge them to fulfill in so remarkable though diversified a way their different destinies. One thing is clear to demonstration, that by these creatures and their instincts, the power, wisdom and goodness of the GREAT FATHER of the universe are loudly proclaimed; the atheist and infidel confuted; the believer confirmed in

his faith and trust in Providence, which he thus beholds watching, with incessant care, over the welfare of the meanest of his creatures; and from which he may conclude that he, the prince of the creation, will never be overlooked or forsaken: and from them what lessons may be learned of patriotism and self-devotion to the public good; of loyalty; of prudence, temperance, diligence, and self-denial.—But it is time at length to put an end to this long disquisition.

I am, &c.

LETTER XXI.

MEANS BY WHICH INSECTS DEFEND THEMSELVES.

WHEN a country is particularly open to attack, or surrounded by numerous enemies, who from cupidity or hostile feelings are disposed to annoy it, we are usually led to inquire what are its means of *defence?* whether natural, or arising from the number, courage, or skill of its inhabitants. The insect tribes constitute such a nation: with them infinite hosts of enemies wage continual war, many of whom derive the whole of their subsistence from them: and amongst their own tribes there are numerous civil broils, the strong often preying upon the weak, and the cunning upon the simple: so that unless a watchful Providence (which cares for all its creatures, even the most insignificant,) had supplied them with some mode of resistance or escape, this innumerable race must soon be extirpated. That such is the case, it shall be my endeavour in this letter to prove; in which I shall detail to you some of the most remarkable means of defence with which they are provided. For the sake of distinctness I shall consider these under two separate heads, into which indeed they naturally divide themselves:—*Passive* means of defence, such as are independent of any efforts of the insect; and *active* means of defence, such as result from certain efforts of the insect in the employment of those instincts and

instruments with which Providence has furnished it for this purpose.

I. The principal *passive* means of defence with which insects are provided, are derived from their colour and form, by which they either deceive, dazzle, alarm, or annoy their enemies; or from their substance, involuntary secretions, vitality, and numbers.

They often *deceive* them by imitating various substances. Sometimes they so exactly resemble the soil which they inhabit, that it must be a practised eye which can distinguish them from it. Thus, one of our scarcest British weevils (*Curculio nebulosus*, L.), by its grey colour spotted with black, so closely imitates the soil consisting of white sand mixed with black earth, on which I have always found it, that its chance of escape, even though it be hunted for by the lyncean eye of an entomologist, is not small. Another insect of the same tribe (*Brachyrhinus scabriculus*, F.), of which I have observed several species of common dors (*Harpalus*, Latr.) make great havoc, abounds in pits of a loamy soil of the same colour precisely with itself; a circumstance that doubtless occasions many to escape from their pitiless foes.—Several other weevils, for instance *Brachyrhinus niveus* and *cretaceus*, F., resemble chalk, and perhaps inhabit a chalky or white soil.

Many insects also are like pebbles and stones, both rough and polished, and of various colours; but since this resemblance sometimes results from their attitudes, I shall enlarge upon it under my second head: whether, however, it be merely passive, or combined with action, we may safely regard it as given to enable them to elude the vigilance of their enemies.

A numerous host of our little animals escape from birds and other assailants by imitating the colour of the plants, or parts of them, which they inhabit; or the twigs of shrubs and trees; their foliage, flowers, and fruit. Many of the mottled moths, which take their station of diurnal repose on the north side of the trunks of trees, are with difficulty distinguished from the gray and green lichens that cover them. Of this kind are *Noctua aprilina* and *Psi*, F. The caterpillar of *N. Algæ*, F. when it feeds on the yellow *Lichen juniperinus*, is always yellow; but when upon the gray *Lichen saxatilis* its hue becomes gray[a]. This change is probably produced by the colour of its food. *Phryganea atra*, a kind of may-fly, frequents the black flower-spikes of the common sedge (*Carex riparia*), which fringes the banks of our rivers. I have often been unable to distinguish it from them, and the birds probably often make the same mistake and pass it by.—A jumping bug, very similar to one figured by Schellenberg[b], also much resembles the lichens of the oak on which I took it.

The Spectre tribe (*Phasma*, Licht.) go still further in this mimicry, representing a small branch with its spray. I have one from Brazil eight inches long, that, unless it was seen to move, could scarcely be conceived to be any thing else; the legs, as well as the head, having their little snags and knobs, so that no imitation can be more accurate. Perhaps this may be the species mentioned by Molina[c], which the natives of Chili call "The Devil's Horse[d]."

[a] Fabr. *Vorlesungen*, 321. [b] *Cimic. Helvet. t.* iii. *f.* 3.

[c] *Hist. of Chili*, i. 172.

[d] Since the first edition of this volume was printed, a lady from the West Indies looking at my cabinet, upon being shown this insect, exclaimed "Oh, that is *The Devil's Horse!*"

Other insects, of various tribes, represent the leaves of plants, living, decaying, and dead; some in their colour, and some both in their colour and shape. The caterpillar of a moth (*Noctua Ligustri*, F.) that feeds upon the privet, is so exactly of the colour of the underside of the leaf, upon which it usually sits in the daytime, that you may have the leaf in your hand and yet not discover it[a].—The tribe of grasshoppers, called *Locustæ* by Fabricius, though the true *Locust* does not belong to it, in the veining, colour, and texture of their elytra, resemble green leaves[b].—The genera *Mantis* and *Phasma*—named praying-insects and spectres—also of the *Orthoptera* order, often exhibit the same peculiarity.—Others of them, by the spots and mixtures of colour observable in these organs, represent leaves that are decaying in various degrees.—Those of several species of *Mantis* likewise imitate dry leaves, and so exactly, by their opacity, colour, rigidity, and veins, that, were no other part of the animal visible, even after a close examination, it would be generally affirmed to be nothing but a dry leaf. Of this nature is the *Mantis siccifolia*, F., and two or three Brazilian species in my cabinet, that seem undescribed, which I will show you when you give me an opportunity. But these imitations of dry leaves are not confined to the *Orthoptera* order solely. Amongst the *Hemiptera*, the *Coreus paradoxus*, F., a kind of bug, surprised Sparrman not a little. He was sheltering himself from the mid-day sun, when the air was so still and calm

[a] Brahm *Insekten Kalender*, ii. 383.

[b] Hence we have *Locusta citrifolia, laurifolia, camellifolia, myrtifolia, salvifolia*, &c.

as scarcely to shake an aspen leaf, and saw with wonder what he mistook for a little withered, pale, crumpled leaf, eaten as it were by caterpillars, fluttering from the tree. The sight appeared to him so very extraordinary, that he left his place of shelter to contemplate it more nearly; and could scarcely believe his eyes, when he beheld a living insect, in shape and colour resembling a fragment of a withered leaf with the edges turned up and eaten away as it were by caterpillars, and at the same time all over beset with prickles [a].—A British insect, one of our largest moths (*Bombyx quercifolia*, F.) called by collectors the *lappet-moth*, affords an example from the *Lepidoptera* order of the imitation in question, its wings representing, both in shape and colour, an arid brown leaf. Some bugs, belonging to the genus *Tingis*, F., simulate portions of leaves in a still further state of decay, when the veins only are left. For, the thorax and elytra of these insects being reticulated, with the little areas or meshes of the net-work transparent, this circumstance gives them exactly the appearance of small fragments of skeletons of leaves.

But you have probably heard of most of these species of imitation: I hope, therefore, you will give credit to the two instances to which I shall next call your attention, of insects that even mimic flowers and fruit. With respect to the former, I recollect to have seen in a collection made by Mr. Masson at the Cape of Good Hope, a kind of *Pneumora*, Thunb.—arranged by Linné with the grass-hoppers (*Gryllus*)—the elytra of which were of a rose- or pink-colour, which shrowding its vesiculose abdomen,

[a] *Voyage*, &c. ii. 16.

gave it much the appearance of a fine flower—A most beautiful and brilliant beetle, of the genus *Chlamys*, Knoch, (*Ch. Bacca*, Kirby) found by Captain Hancock in Brazil, by the inequalities of its ruby-coloured surface, strikingly resembles some kinds of fruit.—And to make the series of imitations complete, a minute black beetle, with ridges upon its elytra, (*Hister sulcatus*, Oliv.)[a], when lying without motion, is very like the seed of an umbelliferous plant. The dog-tick is not unlike a small bean; which resemblance has caused a bean, commonly cultivated as food for horses, to be called the *tick-bean*. The Palma Christi, also, had probably the name of *Ricinus* given to it from the similitude of its seed to a tick.

Another tribe of these little animals, before alluded to, is secured from harm by a different kind of imitation, and affords a beautiful instance of the wisdom of Providence in adapting means to their end. Some singular larvæ, with a radiated anus[b], live in the nests of humble-bees, and are the offspring of a particular genus of flies, (*Volucella*, Geoffr., *Pterocera*, Meigen,) many of the species of which strikingly resemble those bees in shape, clothing, and colour. Thus has the Author of nature provided that they may enter these nests and deposit their eggs undiscovered. Did these intruders venture themselves amongst the humble-bees in a less kindred form, their lives would probably pay the forfeit of their presumption. Mr. Sheppard once found one of these larvæ in the nest of *Apis Raiella*, K., but we could not ascertain what the fly was. Perhaps it

[a] Oliv. *Entomolog.* i. no. 8. 17.

[b] PLATE XIX. FIG. 11. VOL. I. 4th Ed. 264. Latreille, *Gen. Crust. et Ins.* iv. 322.

might be *Pterocera bombylans*, Meig., which resembles those humble-bees that have a red anus.

The brilliant colours in which many insects are arrayed, may decorate them with some other view than that of mere ornament. They may *dazzle* their enemies. The radiant blue of the upper surface of the wings of a giant butterfly, abundant in Brazil (*Papilio Menelaus*, L.), which from its size would be a ready prey for any insectivorous birds, by its splendour (which I am told, when the insect is flying in the sunshine, is inconceivably bright,) may produce an effect upon the sight of such birds, that may give it no small chance of escape. Latreille has a similar conjecture with respect to the golden wasps (*Chrysis*, L.). These animals lay their eggs in the nests of such *Hymenoptera*,—wasps, bee-wasps (*Bembex*, L.), and bees,—as are redoubtable for their stings; and therefore have the utmost occasion for protection against these murderous weapons. Amongst other defences the golden wasps are adorned with the most brilliant colours, which by their radiance, especially in the sunny situations frequented by these insects, may dazzle the eyes of their enemies, and enable them to effect unhurt the purpose for which they were created[a].

The frightful aspect of certain insects is another passive mean of defence by which they sometimes strike beholders, especially children, often great insect tormentors, with *alarm*, and so escape. The terrific and protended jaws of the stag-beetle (*Lucanus Cervus*, L.) in Europe, and of the stag-horn capricorn beetle (*Prionus cervicornis*, F.) in America, may save them from the cruel fate of

[a] Latreille, *Annal. du Mus.* 1810. 5.

the poor cockchafer[a], whose gyrations and motions, when transfixed by a pin, too often form the amusement of ill-disciplined children. The threatening horns also, prominent eyes, or black and dismal hue of many other *Coleoptera* belonging to the Linnean genera *Scarabæus*, *Cicindela*, and *Carabus*, may produce the same effect.

But the most striking instances of armour are to be found in the *Hemiptera* order amongst the *Cicadiadæ*. In some of these, the horns that rise from the thorax are so singular and monstrous, that nothing parallel to them can be found in nature. Of this kind is the *Cicada spinosa*, Stoll[b], the *Centrotus clavatus*, F.[c], and more particularly the *Centrotus globularis*, F.[d], so remarkable for the extraordinary apparatus of balls and spines, which it appears to carry erect, like a standard, over its head. What is the precise use of all the varieties of armour with which these little creatures are furnished it is not easy to say, but they may probably defend them from the attack of some enemies.

Under this head I may mention the long hairs, stiff bristles, sharp spines, and hard tubercular prominences with which many caterpillars are clothed, bristled, and studded. That these are means of defence is rendered more probable by the fact that, in several instances, the animals so distinguished, at their last moult, previous to their assuming the pupa, (in which state they are pro-

[a] One would almost wish that the same superstition prevailed here which Sparrman observes is common in Sweden, with respect to these animals. "Simple people," says he, "believe that their sins will be forgiven if they set a cockchafer on its legs." *Voyage*, i. 28.

[b] *Cigales*, *f*. 85.

[c] Ibid. *f*. 115. Coquebert, *Illustr. Ic.* ii. *t*. xxviii. *f*. 5.

[d] Stoll, *Cigales*, *f*. 163. Comp. Pallas, *Spicil. Zool. t*. i. *f*. 12.

tected by other contrivances,) appear with a smooth skin, without any of the tubercles, hairs, or spines for which they were before remarkable[a]. Wonderful are the varieties of this kind which insects exhibit:—but upon these I shall treat more at large on a future occasion. I shall only here select a few facts more particularly connected with my present subject. The caterpillar of the great tiger-moth (*Bombyx Caja*, F.), which is beset with long dense hair, when rolled up—an attitude it usually assumes if alarmed—cannot then be taken without great difficulty, slipping repeatedly from the pressure of the fingers. If its hairs do not render it distasteful, this may often be the mean of its escape from the birds.—That little destructive beetle, *Anthrenus Museorum*, F., which so annoys the entomologist, if it gets into his cabinets, when in the larva state, being covered with bunches of diverging hairs, glides from between your fingers as if it were lubricated with oil. The two tufts of hairs near the tail of this are most curious in their structure, being jointed through their whole length, and terminating in a sharp halberd-shaped point[b].—I have a small lepidopterous caterpillar from Brazil, the upper side of which is thickly beset with strong, sharp, branching spines, which would enter into the finger, and would probably render it a painful morsel to any minor enemy.

The powers of *annoyance*, by means of their hair, with which the moth of the fir, and the procession-moth, be-

[a] Reaum. v. 94.

[b] This was first pointed out to me by Mr. Briggs of the Post-office, who sent me an accurate drawing of the animal and of one of its hairs. I did not at that time discover that it had been figured by De Geer, iv. *t.* viii. *f.* 1-7.

fore noticed[a], are gifted, are doubtless a defensive armour to them.—Madame Merian has figured an enormous caterpillar of this kind,—which unfortunately she could not trace to the perfect insect,—by the very touch of which her hands, she says, were inflamed, and that the inflammation was succeeded by the most excruciating pain[b]. The vesicatory beetles, likewise, (*Lytta vesicatoria*, F., &c.) are not improbably defended from their assailants by the remarkable quality, so useful to suffering mortals, that distinguishes them.

Your own observation must have proved to you, that insects often escape great perils, from the crush of the foot, or of superincumbent weights, by the hardness of the *substance* that covers great numbers of them. The elytra of many beetles of the genus *Hister* are so nearly impenetrable, that it is very difficult to make a pin pass through them; and the smaller stag-beetle (*Lucanus parallelopipedus*, L.) will bear almost any weight—the head and trunk forming a slight angle with the abdomen—which passes over it upon the ground. Other insects are protected by the toughness of their skin. A remarkable instance of this is afforded by the common forest-fly (*Hippobosca equina*, L.), which, as was before observed[c], can scarcely be killed by the utmost pressure of the finger and thumb.

The *involuntary secretions* of these little beings may also be regarded as means of defence, which either con-

[a] Vol. I. 4th Ed. p. 130, 131.

[b] *Insect. Surinam. t.* 57. Two different species of caterpillars apparently related to this of Madame Merian were in the late Mr. Francillon's cabinet, and are now in my possession.

[c] Vol. I. 4th Ed. p. 148.

ceal them from their enemies, make them more difficult to be attacked, or render them less palatable. Thus, the white froth often observable upon rose-bushes, and other shrubs and plants, called by the vulgar frog-spittle,—but which, if examined, will be found to envelop the larva of a small hemipterous insect (*Cicada spumaria*, L.), from whose anus it exudes, although it is sometimes discovered even in this concealment by the indefatigable wasps, and becomes their prey,—serves to protect the insect, which soon dies when exposed, not only from the heat of the sun and from violent rains, but also to hide it from the birds and its other foes.—The cottony secretion that transpires through the skin of many species of *Aphis*, *Chermes*, and *Coccus*, and in which the eggs of the latter are often involved, may perhaps be of use to them in this view; either concealing them—for they look rather like little locks of cotton, or feathers, than any thing animated—or rendering them distasteful to creatures that would otherwise prey upon them.—The same remark may apply to the slimy caterpillars of some of the saw-flies (*Tenthredo.* L., *T. Cerasi*, *Scrophulariæ*, *&c.*). The coat of slime of these animals, as Professor Peck observes[a], retains its humidity though exposed to the fiercest sun.—Under this head I shall also mention the phosphoric insects: the glow-worm (*Lampyris*); the lantern-fly (*Fulgora*); the fire-fly (*Elater*); and the electric centipede (*Scolopendra electrica*, L.); since the light emitted by these animals may defend them from the attack of some enemies. Mr. Sheppard once noticed a Carabus running round the last-mentioned insect. when shining, as if wishing but afraid to attack it.

[a] *Nat. Hist. of the Slug-worm*, 7.

Various insects, doubtless, find the wonderful *vitality*[a] with which they are endowed another mean of defence; at least of obviating the effects of an attack. So that, when to all appearance they are mortally wounded, they recover, and fulfil the end of their creation. Indeed female *Lepidoptera*, especially of the larger kinds, will scarcely die, do what you will, till they have laid their eggs.—Dr. Arnold, a most acute observer, relates to Mr. MacLeay, that having pinned *Scolia quadrimaculata*, F., a hymenopterous insect, down in the same box with many others, amongst which was the humming-bird hawk-moth (*Sphinx stellatarum*, L.), its proper food; it freed itself from the pin that transfixed it, and, neglecting all the other insects in the box, attacked the Sphinx, and pulling it to pieces devoured a large portion of its abdomen.

We often wonder how the cheese-mite (*Acarus Siro*, L.) is at hand to attack a cheese wherever deposited; but when we learn from Leeuwenhoek, that one lived eleven weeks gummed on its back to the point of a needle without food, our wonder will be diminished[b]. Another species of mite (*A. vegetans*, L.) was observed by De Geer to live some time in spirits of wine[c]. This last circumstance reminds me of an event which befel myself, that I cannot refrain from relating to you, since it was the cause of my taking up the pursuit I am recommend-

[a] The penetrating genius of Lord Verulam discovered in a great degree the cause of this vitality. "They stirre," says he, speaking of insects, "a good while after their heads are off, or that they be cut in pieces; which is caused also for that their vital spirits are more diffused thorowout all their parts, and lesse confined to organs than in perfect creatures." *Sylv. Sylvar. cent.* vii. § 697.

[b] Leeuw. *Epist.* 77, 1694.

[c] De Geer, vii. 127.

ing to you. One morning I observed on my study window a little lady-bird yellow with black dots (*Coccinella 22-punctata*, L.)—"You are very pretty," said I to myself, "and I should like to have a collection of such creatures." Immediately I seized my prey, and not knowing how to destroy it, I immersed it in geneva. After leaving it in this situation a day and a night, and seeing it without motion, I concluded it was dead, and laid it in the sun to dry. It no sooner, however, felt the warmth than it began to move, and afterward flew away. From this time I began to attend to insects.—The chamæleon-fly (*Stratyomis Chamæleon*, F.) was observed by Swammerdam to retain its vital powers after an immersion equally long in spirits of wine. Gœdart affirms that this fly, on which account it was called chamæleon, will live nine months without food; a circumstance, if true, more wonderful than what I formerly related to you with respect to one of the aphidivorous flies[a].—If insects will escape unhurt from a bath of alcohol, it may be supposed that one of water will be less to be dreaded by them. To this they are often exposed in rainy weather, when ruts and hollows are filled with water: but when the water is dried up, it is seldom that any dead carcases of insects are to be seen in them. Mr. Curtis submerged the fragile aphides for sixteen hours; when taken out of the water they immediately showed signs of life, and out of four, three survived the experiment:—an immersion of twenty-four hours, however, proved fatal to them[b].

The late ingenious, learned, and lamented Dr. Reeve of Norwich once related to me that he found in a hot

[a] *Bib. Nat.* ii. c. 3. Vol. I. 4th Ed. p. 400.
[b] *Linn. Trans.* vi. 84.

fountain on the top of a mountain, near Leuk in the Valais in Switzerland, in which the thermometer stood at 205°, transparent larvæ, probably of gnats, or some such insect.—Lord Bute also, in a letter to my late revered friend, the Rev. William Jones of Nayland, imparts a similar observation made by His Lordship at the baths of Abano, near the Euganian mountains, on the borders of the Paduan states. They are strong, sulphureous, boiling springs, oozing out of a rocky eminence in great numbers, and spreading over an acre of the top of a gentle hill. In the midst of these boiling springs, within three feet of five or six of them, rises a tepid one about blood warm. But the most extraordinary circumstance which he relates is, that not only confervas were found in the *boiling* springs, but numbers of small black beetles, that died upon being taken out and plunged into cold water[a].—And once, having taken in the hot dung of my cucumber-bed a small beetle (*Lyctus Juglandis*, F.), I immersed it in boiling water; and after keeping it submerged a sufficient time, as I thought, to destroy it, upon taking it out, and laying it to dry, it soon began to move and walk. Its native station being of so high a temperature, Providence has fitted it for it, by giving it extraordinary powers of sustaining heat. Other insects are as remarkable for bearing any degree of cold. Some gnats that De Geer observed, survived after the water in which they were was frozen into a mass of ice: and Reaumur relates many similar instances[b].

The last passive means of defence that I mentioned,

[a] J. Mason Good's *Anniversary Oration, delivered March* 8, 1808, *before the Medical Society of London*, p. 31.

[b] De Geer, vi. 355; comp. 320, and Reaum. ii. 141-147.

was the *multiplication* of insects. Some species, the Aphides for instance, and the Grasshoppers and Locusts, have such an infinite host of enemies, that were it not for their numbers the race would soon be annihilated. —But as passive means of defence have detained us sufficiently long, it is enough to have touched upon this head. Let us then now proceed to such as may be called active; in which the volition of the animal bears some part.

II. The *active* means of defence, which tend to secure insects from injury or attack, are much more numerous and diversified than the passive; and also more interesting, since they depend, more or less, upon the efforts and industry of these creatures themselves. When urged by danger, they endeavour to repel it either by having recourse to certain attitudes or motions; producing particular noises; emitting disagreeable scents or fluids; employing their limbs; or weapons, and valour; concealing themselves in various ways; or by counteracting the designs and attack of their enemies by contrivances that require ingenuity and skill.

The *attitudes* which insects assume for this purpose are various. Some are purely imitative, as in many instances detailed above. I possess a diminutive rove-beetle (*Aleochara complicans*, K. Ms.) to which my attention was attracted as a very minute, shining, round, black pebble. This successful imitation was produced by folding its head under its breast, and turning up its abdomen over its elytra; so that the most piercing and discriminating eye would never have discovered it to be an insect.—I have observed that a carrion beetle (*Silpha thoracica*, L.) when alarmed has recourse to a similar

manœuvre. Its orange-coloured thorax, the rest of the body being black, renders it particularly conspicuous. To obviate this inconvenience, it turns its head and tail inwards till they are parallel with the trunk and abdomen, and gives its thorax a vertical direction, when it resembles a rough stone.—The species of another genus of beetles (*Agathidium*, F.) will also bend both head and thorax under the elytra, and so assume the appearance of shining globular pebbles.

Related to the defensive attitude of the two last-mentioned insects, and precisely the same with that of the Armadillo (*Dasypus*, L.) amongst quadrupeds, is that of one of the species of woodlouse (*Armadillo vulgaris*, Latr.). This insect when alarmed rolls itself up into a little ball. In this attitude its legs and the underside of the body, which are soft, are entirely covered and defended by the hard crust that forms the upper surface of the animal. These balls are perfectly spherical, black, and shining, and belted with narrow white bands, so as to resemble beautiful beads; and could they be preserved in this form and strung, would make very ornamental necklaces and bracelets. At least so thought Swammerdam's maid, who, finding a number of these insects thus rolled up in her master's garden, mistaking them for beads, employed herself in stringing them on a thread; when, to her great surprise, the poor animals beginning to move and struggle for their liberty, crying out and running away in the utmost alarm she threw down her prize[a].—The golden-wasp tribe also, (*Chrysis* and *Parnopes*, F.) all of which I suspect to be parasitic insects, roll themselves up, as I have often observed, into a little

[a] Hill's *Swamm.* i. 174.

ball when alarmed, and can thus secure themselves—the upper surface of the body being remarkably hard, and impenetrable to their weapons—from the stings of those *Hymenoptera* whose nests they enter with the view of depositing their eggs in their offspring. Latreille noticed this attitude in *Parnopes carnea*, which, he tells us, *Bembex rostrata* pursues, though it attacks no other similar insect, with great fury; and, seizing it with its feet, attempts to dispatch it with its sting, from which it thus secures itself[a].

Other insects endeavour to protect themselves from danger by simulating death. The common dung-chafer (*Geotrupes stercorarius*, Latr.) when touched, or in fear, sets out its legs as stiff as if they were made of iron-wire —which is their posture when dead—and remaining perfectly motionless, thus deceives the rooks which prey upon them, and like the ant-lion before celebrated[b] will eat them only when alive. A different attitude is assumed by one of the tree-chafers (*Hoplia pulverulenta*) probably with the same view. It sometimes elevates its posterior legs into the air, so as to form a straight vertical line, at right angles with the upper surface of its body.—Another genus of insects of the same order, the pill-beetles (*Byrrhus* F., *Cistela* Marsh.), have recourse to a method the reverse of this. They pack their legs, which are short and flat, so close to their body, and lie so entirely without motion when alarmed, that they look like a dead body, or rather the dung of some small animal.—Amongst the weevil tribe, the species of Illiger's genus *Cryptorynchus* (*Rynchænus* F., *Curculio* Latr.),

[a] *Ann. du Mus.* 1810. 5.

[b] Vol. I. 4th Ed. p. 428.

when an entomological finger approaches them, as I have often experienced to my great disappointment, applying their rostrum and legs to the underside of their trunk, fall from the station on which you hope to entrap them, to the ground or amongst the grass; where, lying without stirring a limb, they are scarcely to be distinguished from the soil around them. Thus also, doubtless, they often disappoint the birds as well as the entomologist.—A little timber-boring beetle (*Anobium pertinax*, F.), (and others of the genus have the same faculty,) which, when the head is withdrawn somewhat within the thorax, much resembles a monk with his hood, has long been famous for a most pertinacious simulation of death. All that has been related of the heroic constancy of American savages, when taken and tortured by their enemies, scarcely comes up to that which these little creatures exhibit. You may maim them, pull them limb from limb, roast them alive over a slow-fire[a], but you will not gain your end; not a joint will they move, nor show by the least symptom that they suffer pain. Do not think, however, that I ever tried these experiments upon them myself, or that I recommend you to do the same. I am content to believe the facts that I have here stated upon the concurrent testimony of respectable witnesses, without feeling any temptation to put the constancy of the poor insect again to the test.—A similar apathy is shown by some species of saw-fly (*Tenthredo*, L.), which when alarmed conceal their antennæ under their body, place their legs close to it, and remain without motion even when transfixed by

[a] De Geer, iv. 229.

a pin.—Spiders also simulate death by folding up their legs, falling from their station, and remaining motionless; and when in this situation, they may be pierced and torn to pieces without their exhibiting the slightest symptom of pain[a].

There is a certain tribe of caterpillars called surveyors (*Geometræ*), that will sometimes support themselves for whole hours, by means of their posterior legs, solely upon their anal extremity, forming an angle of various degrees with the branch on which they are standing, and looking like one of its twigs. Many concurring circumstances promote this d eception. The body is kept stiff and immoveable with the separations of the segments scarcely visible; it terminates in a knob, the legs being applied close, so as to resemble the gem at the end of a twig; besides which, it often exhibits intermediate tubercles which increase the resemblance. Its colour too is usually obscure, and similar to that of the bark of a tree. So that, doubtless, the sparrows and other birds are frequently deceived by this manœuvre, and thus balked of their prey. Rösel's gardener, mistaking one of these caterpillars for a dead twig, started back in great alarm when upon attempting to break it off he found it was a living animal[b].

But insects do not always confine themselves to attitudes by which they meditate escape or concealment; they sometimes, to show their courage, put themselves in a posture of defence, and even have in view the annoyance as well as the repelling of their foes. The great rove-beetle (*Staphylinus olens*, F.) presents an object sufficiently terrific, when with its large jaws expanded, and its abdomen turned over its head, like a scorpion, it menaces its

[a] Smellie, *Phil. of Nat. Hist.* i. 150. [b] Rös. I. v. 27.

enemies, some of which this ferocious attitude may deter from attacking it. Mr. Bingley informs us that the giant earwig (*Forficula gigantea*, F.), a rare species that his researches have added to the catalogue of British insects, turns up over its head, in a similar manner, its abdomen, which being armed at the end with a large forceps must give it an appearance still more alarming[a].

The caterpillars of some hawk-moths (*Sphinx*, L.), particularly that which feeds upon the privet, when they repose, holding strongly with their prolegs the branch on which they are standing, rear the anterior part of their body so as to form nearly a right angle with the posterior; and in this position it will remain perfectly tranquil,—thus eluding the notice of its enemies, or alarming them,—perhaps for hours. Reaumur relates that a gardener in the employment of the celebrated Jussieu used to be quite disconcerted by the self-sufficient air of these animals, saying they must be very proud, for he had never seen any other caterpillars hold their head so high[b]. From this attitude, which precisely resembles that which sculptors have assigned to the fabulous monster called by that name, the term *Sphinx* has been used to designate this genus of insects.—The caterpillar of a moth (*Bombyx camelina*, F.) noticed by the author just quoted, whenever it rests from feeding, turns its head over its back, then become concave, at the same time elevating its tail, the extremity of which remains in a horizontal position, with two shorts horns like ears behind it. Thus the six anterior legs are in the air, and the whole animal looks like a quadruped in miniature; the tail being its head—the

[a] PLATE I. FIG. 7. *Linn. Trans.* x. 404— [b] Reaum. ii. 253.

horns its ears—and the reflexed head simulating a tail curled over its back[a]. In this seemingly unnatural attitude it will remain without motion for a very long time.

Some lepidopterous larvæ, that fix the one half of the body and elevate the other, agitate the elevated part, whether it be the head or the tail, as if to strike what disturbs them[b]. The giant caterpillar of a large North American moth (*Bombyx regalis*, F.) is armed behind the head and at the back of the anterior segments with seven or eight strong curved spines from half to three-fourths of an inch in length. Mr. Abbot tells us that this caterpillar is called in Virginia the hickory-horned devil, and that when disturbed it draws up its head, shaking or striking it from side to side; which attitude gives it so formidable an aspect, that no one, he affirms, will venture to handle it, people in general dreading it as much as a rattle-snake. When, to convince the Negroes that it was harmless, he himself took hold of this animal in their presence, they used to reply that it could not sting him, but would them[c]. The species of a genus of beetles separated from *Cantharis*, L., under the name of *Malachius*, F., endeavour to alarm their enemies and show their rage by puffing out and inflating four vesicles from the sides of their body, which are of a bright red, soft, and of an irregular shape. When the cause of alarm is removed, they are retracted, so that only a small portion of them appears[d].

Insects often endeavour to repell or escape from assailants by their *motions*. Mr. White, mentioning a wild bee that makes its nest on the summit of a remarkable hill

[a] Reaum. ii. 260. *t.* 20. *f.* 10. 11. Compare Sepp. IV. *t.* i. *f.* 3-7.
[b] Ibid. i. 100.
[c] Smith's *Abbot's Ins. of Georgia*, ii. 121.
[d] De Geer, iv. 74.

near Lewes in Sussex, in the chalky soil, says: "When people approach the place these insects begin to be alarmed, and with a sharp and hostile sound dash and strike round the heads and faces of intruders. I have often been interrupted myself while contemplating the grandeur of the scenery around me, and have thought myself in danger of being stung[a]."—The hive-bee will sometimes have recourse to the same expedient, when her hive is approached too near, and thus give you notice what you may expect if you do not take her warning and retire.—Humble-bees when disturbed, whether out of the nest or in it, assume some very grotesque and at the same time threatening attitudes. If you put your finger to them, they will either successively or simultaneously lift up the three legs of one side; turn themselves upon their back; bend up their anus and show their sting accompanied by a drop of poison. Sometimes they will even spirt out that liquor. When in the nest, if it be attacked, they also beat their wings violently and emit a great hum[b].

These motions menace vengeance; those of some other insects are merely to effect their escape. Thus I have observed that the species of the May-fly tribe (*Phryganea* L., *Trichoptera* K.[c]), when I have attempted to take them, have often glided away from under my hand —without moving their limbs that I could discover—in a remarkable manner. I once observed a weevil (*Brachyrhinus*, F.) upon a rail, which, when it saw me, slided sideways, and then rolled off. To notice the ordinary motions of insects, which are often means by which they

[a] *Nat. Hist.* ii. 268.
[b] P. Huber in *Linn. Trans.* vi. 219. Kirby, *Mon. Ap. Angl.* i. 201.
[c] Kirby in *Linn. Trans.* xi. 87, note*.

escape from danger, would here be premature, since they will be fully considered in a subsequent letter. I shall therefore only mention the zigzag flight of butterflies and the traverse sailing of humble-bees, which certainly render it more difficult for the birds to catch them while on the wing.

Noises are another mean of defence to which insects have occasional recourse. I have heard the lunar dung-beetle (*Copris lunaris*, F.) when disturbed utter a shrill sound. *Dynastes Oromedon*, another of the lamellicorn insects, was observed by Dr. Arnold to make, when alarmed, a kind of creaking noise, which it produced by rubbing its abdomen against its elytra. A third of the same tribe, *Trox sabulosus*, F., emits a small sibilant or chirping noise, as I once observed when I found several feeding in a ram's horn. The "drowsy hum" of beetles, humble-bees, and other insects, in their flight, may tend to preserve them from some of their aërial assailants. And the angry chidings of the inhabitants of the hive, which are very distinguishable from their ordinary sounds, may be regarded as warning voices to those from whom they apprehend evil or an attack. I have before observed that the death's-head hawk-moth (*Sphinx Atropos*, L.), when menaced by the stings of ten thousand bees enraged at her depredations upon their property, possesses the secret to disarm them of their fury[a]. This insect, when in fear or danger, is known to produce a sharp, shrill, mournful cry, which with the superstitious has added to the alarm produced by the symbol of death which signalizes its thorax[b]. This cry, there is reason to believe, affects and

[a] Vol. I. 4th Ed. p. 163. [b] Ibid. 34.

disarms the bees, so as to enable her to proceed in her spoliations with impunity[a]. One of these insects being once brought to a learned divine, who was also an entomologist, when he was unwell, he was so much moved by its plaintive noise, that, instead of devoting it to destruction, he gave the animal its life and liberty. I might say more upon this subject of defensive noises: but I shall reserve what I have further to communicate, to a letter which I purpose devoting to the sounds produced or emitted by insects.

You are acquainted with the singular property of the skunk (*Viverra putorius*, L.), which repels its assailants by the fetid vapour that it explodes; but perhaps are not aware that the Creator has endowed many insects with the same property and for the same purpose—some of which exhale powerful or disagreeable *odours* at all times, and from the general surface of their body; while they issue from others only through particular organs, and when they are attacked.

Of the former description of defensive scents there are numerous examples in almost every order; for, next to plants and vegetable substances, insects, of any part of the creation, afford the greatest diversity of odours. In the *Coleoptera* order a very common beetle, the whirlwig (*Gyrinus Natator*, L.), will infect your finger for a long time with a disagreeable rancid smell; while two other species, *G. minutus* and *villosus*, are scentless.—Those un-

[a] Huber appears to be of this opinion; he does not, however, lay great stress upon it. Yet there seems no other way of accounting for the impunity with which this animal commits its depredations. Huber, ii. 299—

clean feeders, the carrion beetles (*Silphæ*, L.), as might be expected from the nature of their food, are at the same time very fetid.—Pliny tells us of a Blatta,—which, from his description, is evidently the darkling-beetle (*Blaps mortisaga*, F.), and which he recommends as an infallible nostrum, when applied with oil extracted from the cedar, in otherwise incurable ulcers,—that was an object of general disgust on account of its ill scent, a character which it still maintains[a].—Numbers of the *Carabidæ* (a kind of black beetles that run very fast, and are found under stones, and in places that have not a free circulation of air,) exhale a most disagreeable and penetrating odour, which De Geer observes resembles that of rancid butter, and is not soon got rid of. It is produced, he says, from an unctuous matter that transpires through the body[b]; but I am rather inclined to think it proceeds from the extremity.—I have noticed that some small beetles of the *Omalium* genus Grav.—for instance *O. rivulare*, and another species that I once found in abundance on the primrose (*O. Primulæ*, K. Ms.), especially the latter—are abominably fetid when taken, and that it requires more than one washing to free the fingers from it. Every one knows that the cock-roach (*Blatta orientalis*, L.), belonging to the *Orthoptera* order, is not remarkable for a pleasant scent;—but none are more notorious for their bad character in this respect than the bug tribe (*Cimicidæ*), which almost universally exhale an odour that mixes with the scent of cucumbers another extremely unpleasant and annoying. Some however are less disgusting, particularly *Lygæus Hyoscyami*, F., which yields, De Geer found, an

[a] *Hist. Nat.* l. xxix. c. 6. [b] iv. 86.

agreeable odour of thyme[a].—Several lepidopterous larvæ are defended by their ill smell; but I shall only particularize the silk-worms, which on that account are said to be unwholesome.—*Phryganea grandis*, a kind of May fly, is a *trichopterous* insect that offends the nostrils in this way; but a worse is *Hemerobius Perla*, a golden-eyed and lace-winged fly, of the next order, whose beauty is counterbalanced by a strong scent of human ordure that proceeds from it.—Numberless *Hymenoptera* act upon the olfactory nerves by their ill or powerful effluvia. One of them, an ant (*Formica fœtida* De Geer, *fœtens* Oliv.), has the same smell with the insect last mentioned[b]. Our common black ant (*F. fuliginosa*, Latr.), whose curious nests in trees have been before described to you[c], is an insect of a powerful and penetrating scent, which it imparts to every thing with which it comes in contact; and Fabricius distinguishes another (*F. analis*, Latr., *fœtens*, F.) by an epithet (*fœtidissima*) which sufficiently declares its properties. Many wild bees (*Melitta* K., *Andrena* F.) are distinguished by their pungent alliaceous smell. *Crabro U. flavum*, Helw., a wasp-like insect, is remarkable for the penetrating and spirituous effluvia of ether that it exhales[d]. Indeed there is scarcely any species in this order that has not a peculiar scent.—Some dipterous insects—though these in general neither offend nor delight us by it—are distinguished by their smell. Thus *Musca mystacea*, L., a fly that in its grub state lives in cow-dung, savours in this respect, when a denizen of the air, of the substance in which it first drew breath. And another

[a] De Geer, iii. 249. 374. [b] Ibid. 611. [c] Vol. I. 4th Ed. 483.
[d] Kirby, *Mon. Ap. Angl.* i. 136. note *a*.

(*M. cynipsea*, L.) emits a fragrant odour of baum[a].—I have not much to tell you with respect to apterous insects, except that *Iulus terrestris*, a common millepede, leaves a strong and disagreeable scent upon the fingers when handled[b]. Most of the insects I have here enumerated, probably, are defended from some enemy or injury by the strong vapours that exhale from them; and perhaps some in the list produce it from particular organs not yet noticed.

I shall next beg your attention to those insects that emit their smell from particular organs. Of these, some are furnished with a kind of scent-vessels, which I shall call *osmateria*; while in others it issues from the intestines at the ordinary passage. In the former instance the organ is usually retractile within the body, being only exerted when it is used: it is generally a bifid vessel, something in the shape of the letter Y. Linné, in his generic character of the rove-beetles (*Staphylinus*), mentions two oblong vesicles as proper to this genus. These organs,—which are by no means common to the whole genus, even as restricted by late writers,—are its *osmateria*, and give forth the scent for which some species, particularly *S. brunnipes*, are remarkable. If you press the abdomen hard, you will find that these vesicles are only branches from a common stem; and you may easily ascertain that the smell of this insect, which mixes something extremely fetid with a spicy odour, proceeds from their extremity.—A similar organ, half an inch in length, and of the same shape, issues from the neck of the caterpillar of the swallow-tail butterfly (*Papilio Machaon*, L.)[c]. When I pressed this caterpillar, says Bonnet, near its

[a] De Geer, vi. 135. 33. [b] Ibid. vii. 581. [c] Plate XIX. Fig. 1. a.

anterior part, it darted forth its horn as if it meant to prick me with it, directing it towards my fingers; but it withdrew it as soon as I left off pressing it. This horn smells strongly of fennel, and probably is employed by the insect, by means of its powerful scent, to drive away the flies and ichneumons that annoy it. A similar horn is protruded by the slimy larva of *P. Anchises*, L., as also *P. Apollo* and many other *Equites*[a].—Another insect, the larva of a species of saw-fly (*Tenthredo*) described by De Geer, is furnished with osmateria, or scent-organs, of a different kind. They are situated betwen the five first pair of intermediate legs, which they exceed in size, and are perforated at the end like the rose of a watering-pot. If you touch the insect, they shoot out like the horns of a snail, and emit a most nauseous odour, which remains long upon the finger; but when the pressure is removed they are withdrawn within the body[b].—The grub of the poplar-beetle (*Chrysomela Populi*, L.) also is remarkable for similar organs. On each of the nine intermediate dorsal segments of its body is a pair of black, elevated, conical tubercles, of a hard substance; from all of these when touched the animal emits a small drop of a white milky fluid, the smell of which, De Geer observes, is almost insupportable, being inexpressibly strong and penetrating. These drops proceed at the same instant from all the eighteen scent-organs; which forms a curious spectacle. The insect, however, does not waste this precious fluid: each drop instead of falling, after appearing for a moment and dispensing its perfume, is withdrawn again within

[a] Merian *Surinam*. 17. Jones in *Linn. Trans.* ii. 64.

[b] De Geer, ii. 989— *t.* xxxvii. *f.* 6.

its receptacle, till the pressure is repeated, when it reappears[a].

I shall now introduce you to the true counterparts of the skunk, which explode a most fetid vapour from the ordinary passage. I have lately hinted that the scent of many Carabidæ is thus emitted. *Harpalus prasinus*, a beetle of this tribe, combats its enemies with repeated discharges of smoke and noise: but the most famous for their exploits in this way are those, which on this account are distinguished by the name of bombardiers (*Brachinus*, F.). The most common species (*B. crepitans*, F.), which is found occasionally in many parts of Britain, when pursued by its great enemy, *Calosoma Inquisitor*, F., seems at first to have no mode of escape; when suddenly a loud explosion is heard, and a blue smoke, attended by a very disagreeable scent, is seen to proceed from its anus, which immediately stops the progress of its assailant: when it has recovered from the effect of it, and the pursuit is renewed, a second discharge again arrests its course. The bombardier can fire its artillery twenty times in succession if necessary, and so gain time to effect its escape.—Another species (*Brachinus Displosor,*) makes explosions similar to those of *B. crepitans:* when irritated it can give ten or twelve good discharges; but afterwards, instead of smoke it emits a yellow or brown fluid. By bending the joints of its abdomen it can direct its smoke to any particular point. M. Leon Dufour observes that this smoke has a strong and pungent odour, which has a striking analogy with that exhaled by the Nitric Acid. It is caustic,

[a] De Geer, v. 291. Compare Ray's *Letters*, 43. See PLATE XVIII. FIG. 1.

reddening white paper, and producing on the skin the sensation of burning, and forming red spots, which pass into brown, and though washed remain several days[a].

Another expedient to which insects have recourse to rid themselves of their enemies, is the emission of disagreeable *fluids*. These some discharge from the mouth; others from the anus; others again from the joints of the limbs and segments of the body; and a few from appropriate organs.

You have doubtless often observed a black beetle crossing pathways with a slow pace, which feeds upon the different species of bedstraw (*Galium*, L.), called by some the bloody-nose beetle (*Chrysomela tenebricosa*, F.). This insect, when taken, usually ejects from its mouth a clear drop or two of red fluid, which will stain paper of an orange colour. The carrion-beetles (*Silpha* and *Necrophorus*, F.), as also the larger *Carabi*, defile us, if handled roughly, with brown fetid saliva. Mr. Sheppard having taken one of the latter (*C. violaceus*, L.) applied it in joke to his son's face, and was surprised to hear him immediately cry out as if hurt: repeating the experiment with another of his boys, he complained of its making him smart: upon this he touched himself with it, and it caused as much pain as if, after shaving, he had rubbed his face with spirits of wine. This he observed was not invariably the case with this beetle, its saliva at other times being harmless. Hence he conjectures that its caustic nature, in the instance here recorded, might arise from its food; which he had reason to

[a] *Ann. du Mus.* xviii. 70.

think had at that time been the electric centipede (*Scolopendra electrica*, L.).—Lesser having once touched the anal horn of the caterpillar of some sphinx, suddenly turning its head round it vomited upon his hand a quantity of green, viscous, and very fetid fluid, which, though he washed it frequently with soap and fumed it with sulphur, infected it for two days[a].—Lister relates that he saw a spider, when upon being provoked it attempted to bite, emit several times small drops of very clear fluid[b].—Mr. Briggs observed a caterpillar caught in the web of one of our largest spiders, by means of a fluid which it sent forth entirely dissolve the great breadth of threads with which the latter endeavoured to envelop it, as fast as produced, till the spider appeared quite exhausted[c].—The caterpillars also of a particular tribe of saw-flies, remarkable for the beautiful pennated antennæ of the males (*Pteronus* Jurine)[d], when disturbed eject a drop of fluid from their mouth. Those of one species inhabiting the fir-tree (*Pt. Pini*) are ordinarily stationed on the narrow leaves of that tree—which they devour most voraciously in the manner that we eat radishes—with their head towards the point. Sometimes two are engaged opposite to each other on the same leaf. They collect in groups often of more than a hundred, and keep as close to each other as they can. When a branch is

[a] Lesser *L.* i. 284. note 6. [b] *De Araneis* 27.

[c] This gentleman is of opinion that spiders possess the means of re-dissolving their webs. He observed one, when its net was broken, run up its thread, and gathering a considerable mass of the web into a ball, suddenly dissolve it with fluid. He also observes, that when winding up a powerful prey, a spider can form its threads into a broad sheet.

[d] Jurine *Hymenopt. t.* vi. *f.* 8.

stripped they all move together to another. If one of these caterpillars be touched or disturbed, it immediately with a twist lifts the anterior part of its body, and emits from its mouth a drop of clear resin, perfectly similar both in odour and consistence to that of the fir [a]. What is still more remarkable, no sooner does a single individual of the group give itself this motion, than all the rest, as if they were moved by a spring, instantaneously do the same [b]. Thus these animals fire a volley as it were at their annoyers, the scent of which is probably sufficient to discomfit any ichneumons, flies, or predaceous beetles that may be desirous of attacking them.

Amongst those which annoy their enemies by the emission of fluids from their anus are the larger Carabi. These, if roughly handled, will spirt to a considerable distance an acrid, caustic, stinking liquor, which if it touch the eyes or the lips occasions considerable pain [c].—The rose-scented capricorn (*Cerambyx moschatus*, L.) produced a similar effect upon Mr. Sheppard by similar means. The fluid in this had a powerful odour of musk.—The acid of ants has long been celebrated, and is one of their most powerful means of defence. When the species that have no sting make a wound with their jaws, they insinuate into it some of this acid, the effluvia produced by which are so subtile and penetrating, that it is impossible to hold your head near the nest of the hill-ant (*Formica rufa*, L.), when the ants are much disturbed, without being almost suffocated. This odour thus proceeding from myriads of ants, is powerful enough,

[a] De Geer, ii. 971.
[b] I owe the knowledge of this circumstance to Mr. MacLeay.
[c] De Geer, iv. 86. Geoffr. i. 141.

it is said, to kill a frog, and is probably the means of securing the nest from the attack of many enemies.—Dr. Arnold observed a species of bug (*Scutellera*, F.) abundant upon some polygamous plant which he could not determine, and in all their different states. They were attended closely by hosts of ants, and when disturbed emitted a very strong smell. One of these insects ejected a minute drop of fluid into one of his eyes, which occasioned for some hours considerable pain and inflammation. In the evening, however, they appeared to subside;—but on the following morning the inflammation was renewed, became worse than ever, and lasted for three days.

Other insects, when under alarm, discharge a fluid from the joints and segments of their body. You have often seen what has been called the unctuous or oil beetle (*Meloe Proscarabæus*, L.), and I dare say, when you took it, have observed orange-coloured or deep-yellow drops appear at its joints. As these insects feed upon acrid plants, the species of crowfoot or *Ranunculus*, it is probable that this fluid partakes of the nature of their food and is very acrimonious—and thus may put to flight its insect assailants or the birds, from neither of which it could otherwise escape, being a very slow and sluggish and at the same time very conspicuous animal. Another beetle (*Pimelia collaris*, F.)[a] has likewise this faculty.—The lady-bird, we know, has been recommended as a cure for the tooth-ache. This idea may have taken its rise from a secretion of this kind being noticed upon it. I have observed that one species (*Coccinella bipunc-*

[a] Fab. *Ent. Syst. Em.* i. 104. 26. In *Syst. Eleuth.* (i. 135. 5.) it is made an *Akis*.

tata, L.) when taken ejects from its joints a yellow fluid which yields a powerful but not agreeable scent of opium. —*Asilus crabroniformis*, L., a dipterous insect, once when I took it, emitted a white milky fluid from its proboscis, the joints of the legs and abdomen, and the anus. —The common scorpion-fly, likewise, upon the same occasion ejects from its proboscis a brown and fetid drop [a]. Some insects have peculiar organs from which their fluids issue, or are ejaculated. Thus, the larvæ of saw-flies when taken into the hand cover themselves with drops, exuding from all parts of their body, of an unpleasant penetrating scent [b]. That of *Tenthredo lutea*, L. of the same tribe, from a small hole just above each spiracle, syringes a similar fluid in horizontal jets of the diameter of a thread, sometimes to the distance of more than a foot [c].—The caterpillar of the great emperor moth (*Bombyx Pavonia major*, F., *Saturnia Pyri*, Schrank) also spirts out, when the spines that cover them are touched, clear lymph from its pierced tubercles [d].—Willughby has remarked a curious circumstance with respect to a water-beetle (*Dytiscus cinereus*, Marsh.) which ought not to be overlooked. A transverse line of a pale colour is observable upon the elytra of the male; where this line terminates certain oblong pores are visible, from which he affirms he has often seen a milky fluid exuding [e]; and what may confirm his statement, I have more than once observed such a fluid issue from Dytisci of the same family.—The caterpillar of the puss-moth (*Bombyx vinula*), as well as those of several other species, has a

[a] De Geer, ii. 734. [b] Reaumur, v. 96. [c] De Geer, ii. 937—
[d] Rösel, iv. 162. De Geer, i. 273.
[e] Rai. *Hist. Ins.* 94. *n.* 3.

cleft in the neck between the head and the first pair of legs. From this issues, at the will of the animal, a singular syringe, laterally bifid; the branches of which are terminated by a nipple perforated like the rose of a watering-pot. By means of this organ, when touched, it will syringe a fluid to a considerable distance, which, if it enters the eyes, gives them acute but not lasting pain. The animal when taken from the tree on which it feeds, though supplied with its leaves, loses this faculty, with which it is probably endowed to drive off the ichneumons that infest it[a].—And, to name no more, the great tiger-moth (*Bombyx Caja*, F.), when in its last or perfect state, has near its head a remarkable tuft of the most brilliant carmine, from amongst the hairs of which, if the thorax be touched, some minute drops of transparent water issue, doubtless for some similar purpose[b].

The next active means of defence with which Creative Wisdom has endowed these busy tribes, are those *limbs* or *weapons* with which they are furnished. The insect lately mentioned, the puss-moth, besides the syringes just described, is remarkable for its singular forked tail, entirely dissimilar to the anal termination of the abdomen of most other caterpillars. This tail is composed of two long cylindrical tubes moveable at their base, and beset with a great number of short stiff spines. When the animal walks, the two branches of the tail are separated from each other, and at every step are lowered so as to touch the plane of position; hence we may conclude that they assist it in this motion and supply the place of hind legs. If you touch or otherwise incommode it, from

[a] De Geer, i. 324—   [b] Ibid. i. 208.

each of the above branches there issues a long, cylindrical, slender, fleshy, and very flexible organ of a rose colour, to which the caterpillar can give every imaginable curve or inflexion, causing it sometimes to assume even a spiral form. It enters the tube, or issues from it, in the same manner as the horns of snails or slugs. These tails form a kind of double whip, the tubes representing the handle, and the horns the thong or lash, with which the animal drives away the ichneumons and flies that attempt to settle upon it. Touch any part of the body, and immediately one or both the horns will appear and be extended; and the animal will, as it were, lash the spot where it feels that you incommode it. De Geer, from whom this account is taken, says that this caterpillar will bite very sharply [a].—Several larvæ of butterflies, distinguished at their head by a semicoronet of strong spines, figured by Madame Merian, are armed with singular anal organs [b], which may have a similar use. Rösel when he first saw the caterpillar of the puss-moth stretched out his hand with great eagerness, so he tells us, to take the prize; but when in addition to its grim attitude he beheld it dart forth these menacing catapults, apprehending they might be poisonous organs, his courage failed him. At length without touching the monster, he ventured to cut off the twig on which it was, and let it drop into a box [c]! The caterpillar of the gold-tail moth (*Bombyx chrysorhœa*, F.) has a remarkable aperture, which it can open and shut, surrounded by a rim on the upper part of each segment. This aperture includes a little cavity, from which it has the power of

[a] De Geer, i. 322—
[b] *Ins. Surinam.* t. viii. xxiii. xxxii.
[c] I. iv. 122.

darting forth small flocks of a cottony matter that fills it[a]. This manœuvre is probably connected with our present subject, and employed to defend it from its enemies. It also ejects a fluid from its anus.

There is a moth in New Holland, the larva of which annoys its foes in a different way: from eight tubercles in its back it darts forth, when alarmed, as many bunches of little stings, by which it inflicts very painful and venomous wounds[b].

The caterpillar of the moth of the beech (*Bombyx Fagi*, F.), called the lobster, is distinguished by the uncommon length of its anterior legs. Mr. Stephens, an acute entomologist, relates to me that he once saw this animal use them to rid itself of a mite that incommoded it. They are probably equally useful in delivering it from the ichneumon and its other insect enemies.—Dr. Arnold has made a curious observation (confirmed by Dr. Forsström with respect to others of the genus) on the use of the long processes or tails that distinguish the secondary wings of *Hesperia Iarbas*. These processes, he remarks, resemble antennæ, and when the butterfly is sitting it keeps them in constant motion; so that at first sight it appears to have a head at each extremity; which deception is much increased by a spot resembling an eye at the base of the processes. These insects, perhaps, thus perplex or alarm their assailants.—Goedart pretended that the anal horn with which the caterpillars of so many hawk-moths (*Sphinx*) are armed, answers the end of a sting instilling a dangerous venom: but the observations of modern entomologists have proved

[a] Reaum. ii. 155. *t.* vii. *f.* 4–7. [b] Lewin's *Prodromus*.

that this is altogether fabulous, since the animal has not the power of moving them[a]. Their use is still unknown.

Whether the long and often tremendous horns on the head, thorax, and even elytra, with which many insects are armed, are beneficial to them in the view under consideration, is very uncertain. They are often sexual distinctions, and have a reference probably rather to sexual purposes and the economy of the animal, than to any thing else. They may, however, in some instances deter enemies from attacking them, and therefore it was right not to omit them wholly, though I shall not further enlarge upon them.—Their mandibles or upper jaws, though principally intended for mastication,—and in the case of the *Hymenoptera*, as instruments for various economical and mechanical uses,—are often employed to annoy their enemies or assailants. I once suffered considerable pain from the bite of the common water-beetle (*Dytiscus marginalis*, L.), as well as from that of the great rove-beetle (*Staphylinus olens*, F.); but the most tremendous and effectual weapon with which insects are armed —though this, except in the case of the scorpion, is also a sexual instrument, and useful to the females in oviposition —is their sting. With this they keep not only the larger animals, but even man himself, in awe and at a distance. But on these I enlarged sufficiently in a former letter[b].

These weapons, tremendous as they are, would be of but little use to insects if they had not courage to employ

[a] De Geer, i. 149—

[b] Mr. MacLeay relates to me, from the communications of Mr. E. Forster, the following particulars respecting the history of *Mutilla coccinea*, L., which from this account appears to be one of the most redoubtable of stinging inescts. The females are most plentiful in Maryland, in the months of July and August, but are never very nu-

them: in this quality, however, they are by no means deficient; for, their diminutive size considered, they are, many of them, the most valiant animals in nature. The giant bulk of an elephant would not deter a hornet, a bee, or even an ant, from attacking it, if it was provoked. I once observed a small spider walking in my path. On putting my stick to it, it immediately turned round as if to defend itself. On the approach of my finger, it lifted itself up and stretched out its legs to meet it.—In Ray's Letters mention is made of a singular combat between a spider and a toad fought at Hetcorne near Sittinghurst[a] in Kent; but as the particulars and issue of this famous duel are not given, I can only mention the circumstance, and conjecture that the spider was victorious[b]! Terrible as is the dragon-fly to the insect world in general, putting to flight and devouring whole hosts of butterflies, may-flies, and others of its tribes, it instills no terror into the stout heart of the scorpion-fly (*Panorpa communis*, L.), though much its inferior in size and strength. Lyonet saw one attack a dragon-fly of ten times its own bigness, bring it to the ground, pierce it repeatedly with its proboscis; and had he not by his eagerness parted them, he doubts not it would have destroyed this tyrant of the insect creation[c].

When the death's-head hawk-moth was introduced by Huber into a nest of humble-bees, they were not affected by it, like the hive-bees, but attacked it and drove it

merous. They are very active, and have been observed to take flies by surprise. A person stung by one of them lost his senses in five minutes, and was so ill for several days that his life was despaired of.

[a] Hedcorne near Sittingbourne?

[b] Dr. Long in Ray's *Letters*, 370.

[c] Lesser *L.* i. 263. Note ‡.

out of their nest, and in one instance their stings proved fatal to it[a].—A black beetle, probably a *Harpalus* or *Carabus*, devours the eggs of the mole-cricket, or *Gryllotalpa*. To defend them, the female places herself at the entrance of the nest—which is a neatly smoothed and rounded chamber protected by labyrinths, ditches, and ramparts—and whenever the beetle attempts to seize its prey, she catches it and bites it asunder[b].

I know nothing more astonishing than the wonderful muscular strength of insects, which in proportion to their size exceeds that of any other class of animals, and is likewise to be reckoned amongst their means of defence. Take one of the common chafers or dung-beetles (*Geotrupes stercorarius*, or *Copris lunaris*, F.) into your hand, and observe how he makes his way in spite of your utmost pressure; and read the accounts which authors have left us of the very great weights that a flea will easily move, as if a single man should draw a waggon with forty or fifty hundred weight of hay:—but upon this I shall touch hereafter, and therefore only hint at it now.

We are next to consider the modes of *concealment* to which insects have recourse in order to escape the observation of their enemies. One is by covering themselves with various substances. Of this description is a little water-beetle (*Elophorus aquaticus*, F.), which is always found covered with mud, and so when feeding at the bottom of a pool or pond can scarcely be distinguished, by the predaceous aquatic insects, from the soil on which it rests. Another very minute insect of the same order

[a] Huber, *Nouv. Obs.* ii. 301—

[b] Bingley, *Animal Biogr.* iii. 1st Ed. 247— White, *Nat. Hist.* ii. 82.

(*Limnius æneus* Müll., *Elmis* Latr.) that is found in rivulets under stones and the like, sometimes conceals its elytra with a thick coating of mud, that becomes nearly as hard as stone. I never met with these animals so circumstanced but once; then, however, there were several which had thus defended themselves, and I can now show you a specimen.—We have two species of a minute coleopterous genus (*Georyssus*) lately established, one of which, (*G. arenifera* K., *Trox dubius* Panzer,) living in wet spots where the toad-rush (*Juncus bufonius*, L.) grows, covers itself with sand; and another (*G. cretifera*, K.) which frequents chalk, whitens itself all over with that substance[a]. As this animal, when clean, is very black, were it not for this manœuvre, it would be too conspicuous upon its white territory to have any chance of escape from the birds and its other assailants.—No insect is more celebrated for rendering itself hideous by a coat of dirt than the *Reduvius personatus*, F., a kind of bug sometimes found in houses. When in its two preparatory states, every part of its body, even its legs and antennæ, is so covered with the dust of apartments, consisting of a mixture of particles of sand, fragments of wool or silk, and similar matters, that the animal at first would be taken for one of the ugliest spiders. This grotesque appearance is aided and increased by motions equally awkward and grotesque, upon which I shall enlarge hereafter. If you touch it with a hair-pencil or a

[a] A subsequent examination ascertains that these two insects belong to different genera not at present quite determined. The latter, of which I knew two species, I call *Chætophora*, from the scattered bristles with which both are covered.

feather, this clothing will soon be removed, and you may behold the creature unmasked, and in its proper form. It is an insect of prey; and amongst other victims will devour its more hateful congener the bed-bug[a]. Its slow movements, combined with its covering, seem to indicate that the object of these manœuvres is to conceal itself from observation, probably, both of its enemies and of its prey. It is therefore properly noticed under my present head.

As Hercules, after he had slain the Nemean lion, made a doublet of its skin, so the larva of another insect (*Hemerobius Chrysops*, L., a lace-winged fly with golden eyes,) covers itself with the skins of the luckless Aphides that it has slain and devoured. From the head to the tail, this pygmy destroyer of the helpless is defended by a thick coat, or rather mountain composed of the skins, limbs, and down of these creatures. Reaumur, in order to ascertain how far this covering was necessary, removed it, and put the animal into a glass, at one time with a silk cocoon, and at another with raspings of paper. In the first instance, in the space of an hour it had clothed itself with particles of the silk: and in the second, being again laid bare, it found the paper so convenient a material, that it made of it a coat of unusual thickness[b].

Insects in general are remarkable for their cleanliness; —however filthy the substances which they inhabit, yet they so manage as to keep themselves personally neat. Several, however, by no means deserve this character; and I fear you will scarcely credit me when I tell you that

[a] De Geer, iii. 283— Geoffr. *Hist. Ins.* i. 437.
[b] Reaum. iii. 391.

some shelter themselves under an umbrella formed of their own excrement! You will exclaim, perhaps, that there is no parallel case in all nature;—it may be so;—yet as I am bound to confess the faults of insects as well as to extol their virtues, I must not conceal from you this opprobrium. Beetles of three different genera are given to this Hottentot habit. The first to which I shall introduce you is one that has long been celebrated under the name of the beetle of the lily (*Lema merdigera*, F., *Cantaride de' Gigli*, Vallisn.). The larvæ of this insect have a very tender skin, which appears to require some covering from the impressions of the external air and from the rays of the sun; and it finds nothing so well adapted to answer these purposes, and probably also to conceal itself from the birds, as its own excrement, with which it covers itself in the following manner. Its anus is remarkably situated, being on the back of the last segment of the body, and not at or under its extremity, as obtains in most insects. By means of such a position, the excrement when it issues from the body, instead of being pushed away and falling, is lifted up above the back in the direction of the head. When entirely clear of the passage, it falls, and is retained, though slightly, by its viscosity. The grub next, by a movement of its segments, conducts it from the place where it fell to the vicinity of the head. It effects this by swelling the segment on which the excrement is deposited, and contracting the following one, so that it necessarily moves that way. Although, when discharged, it has a longitudinal direction, by the same action of the segments the animal contrives to place every grain transversely. Thus, when laid quite bare, it will

cover itself in about two hours. There are often many layers of these grains upon the back of the insect, so as to form a coat of greater diameter than its body. When it becomes too heavy and stiff, it is thrown off, and a new one begun[a].—The larvæ of the various species of the tortoise-beetles (*Cassida*, L.) have all of them, as far as they are known, similar habits, and are furnished besides with a singular apparatus, by means of which they can elevate or drop their stercorarious parasol so as most effectually to shelter or shade them. The instrument by which they effect this is an anal fork, upon which they deposit their excrement, and which is sometimes turned up and lies flat upon ther backs; at others forms different angles, from very acute to very obtuse, with their body; and occasionally is unbent and in the same direction with it[b]. In some species the excrement is not so disgusting as you may suppose, being formed into fine branching filaments. This is the case with *C. maculata*, L.[c].—In the cognate genus *Imatidium*, the larvæ also are merdigerous; and that of *I. Leayanum*, Latr., taken by Colonel Hardwicke in the East Indies, also produces an assemblage of very long filameuts, that resemble a dried fucus or a filamentous lichen.—The clothing of the *Tineæ*, clothes-moths and others, and also of the case-worms, having enlarged upon in a former letter[d], I need not describe here.

Some insects, that they may not be discovered and become the prey of their enemies when they are reposing, conceal themselves in flowers. The male of a little bee

[a] Reaum. iii. 220— Compare Vallisnieri *Esperienz. ed Osservaz.* 195. Ed. 1726.
[b] Reaum. 233—
[c] Kirby in *Linn. Trans.* iii. 10.
[d] Vol. I. 4th Ed. 460-70.

(*Apis Campanularum* K., *Heriades* Latr.), a true Sybarite, dozes voluptuously in the bells of the different species of *Campanula*—in which, indeed, I have often found other kinds asleep. Linné named another species *florisomnis* on account of a similar propensity. A third, a most curious and rare species (*Melitta spinigera*, K.), shelters itself when sleeping, at least I once found it there so circumstanced, in the nest-like umbel of the wild carrot. You would think it a most extraordinary freak of Nature, should any quadruped sleep suspended by its jaws, (some birds however are said, I think, to have such a habit, and *Sus Babyroussa* one something like it,)—yet insects do this occasionally. Linné informs us that a little bee (*Apis variegata*) passes the night thus suspended to the beak of the flowers of *Geranium phæum*: and I once found one of the vespiform bees (*Apis Goodeniana*, K., *Nomada*, F.) hanging by its mandibles from the edge of a hazel-leaf, apparently asleep, with its limbs relaxed and folded. On being disengaged from its situation it became perfectly lively.

There is no period of their existence in which insects usually are less able to help themselves, than during that intermediate state of repose which precedes their coming forth in their perfect forms. I formerly explained to you how large a portion of them during this state cease to be locomotive, and assume an appearance of death[a]. In this helpless condition, unless Providence had furnished them with some means of security, they must fall an easy prey to the most insignificant of their

[a] Vol. I. 4th Ed. 65—

assailants. But even here they are taught to conceal themselves from their enemies by various and singular contrivances. Some seek for safety by burying themselves, previously to the assumption of the pupa, at a considerable depth under the earth; others bore into the heart of trees, or into pieces of timber; some take their residence in the hollow stalks of plants; and many are concealed under leaves, or suspend themselves in dark places, were they cannot readily be seen. But in this state they are not only defended from harm by the situation they select, but also by the covering in which numbers envelop themselves; for, besides the leathery case that defends the yet tender and unformed imago, many of these animals know how to weave for it a costly shroud of the finest materials, through which few of its enemies can make their way;—and to this curious instinct, as I long since observed, we owe one of the most valuable articles of commerce, the silk that gives lustre to the beauty of our females. These shrouds are sometimes double. Thus the larvæ of certain saw-flies spin for themselves a cocoon of a soft, flexible, and close texture, which they surround with an exterior one composed of a strong kind of net-work, which withstands pressure like a racket[a]. Here nature has provided that the inclosed animal shall be protected by the interior cocoon from the injury it might be exposed to from the harshness of the exterior, while the latter by its strength and tension prevents it from being hurt by any external pressure.

But of all the contrivances by which insects in this

[a] Reaum. v. 100.

state are secured from their enemies, there is none more ingenious that than to which the may-flies (*Phryganea*, L.) have recourse for this purpose. You have heard before that these insects are at first aquatic, and inhabit curious cases made of a variety of materials, which are usually open at each end[a]. Since they must reside in these cases, when they are become pupæ, till the time of their final change approaches, if they are left open, how are the animals, now become torpid, to keep out their enemies? Or, if they are wholly closed, how is the water, which is necessasy to their respiration and life, to be introduced? These sagacious creatures know how to compass both these ends at once. They fix a grate or portcullis to each extremity of their fortress, which at the same time keeps out intruders and admits the water. These grates they weave with silk spun from their anus into strong threads, which cross each other, and are not soluble in water. One of them, described by De Geer, is very remarkable. It consists of a small, thickish, circular lamina of brown silk, becoming as hard as gum, which exactly fits the aperture of the case, and is fixed a little within the margin. It is pierced all over with holes disposed in concentric circles, and separated by ridges which go from the centre to the circumference, but often not quite so regularly as the radii of a circle or the spokes of a wheel. These radii are traversed again by other ridges, which follow the direction of the circles of holes; so that the two kinds of ridges crossing each other form compartments, in the centre of each of which is a hole[b].

[a] Vol. I. 4th Ed. 467--
[b] Reaum. iii. 170. De Geer, ii. 519. 545. Plate XVII. Fig. 11.

Under this head I shall call your attention to another circumstance that saves from their enemies innumerable insects:—I mean their coming forth for flight or for food only in the night, and taking their repose in various places of concealment during the day. The infinite hosts of moths (*Phalæna*, L.),—amounting in this country to more than a thousand species,—with few exceptions, are all night-fliers. And a considerable proportion of the other orders,—exclusive of the *Hymenoptera* and *Diptera*, which are mostly day-fliers,—are of the same description. Many *larvæ* of moths also come out only in the night after their food, lying hid all day in subterraneous or other retreats. Of this kind is that of *Noctua pulla* and *Nycterobius*, whose proceedings have been before described[a]. The caterpillar of another moth (*Noctua subterranea*, F.) never ascends the stems of plants, but remains, a true Troglodyte, always in its cell under ground, biting the stems at their base, which falling, bring thus their foliage within its reach[b].

The habitations of insects are also usually places of retreat, which secure them from many of their enemies:—but I have so fully enlarged upon this subject on a former occasion[c], that it would be superfluous to do more than mention it here.

I am now to lay before you some examples of the contrivances, requiring skill and ingenuity, by which our busy animals occasionally defend themselves from the designs and attack of their foes. Of these I have already detailed to you many instances, which I shall not here

[a] Vol. I. 4th Ed. 456. [b] Fab. *Ent. Syst. Em.* iii. 70. 200.
[c] Vol. I. 4th Ed. 434—

repeat; my history therefore will not be very prolix.—I observed in my account of the societies of wasps, that they place sentinels at the mouth of their nests. The same precaution is taken by the hive-bees, particularly in the night, when they may expect that the great destroyers of their combs, *Tinea mellonella*, F. and its associates[a], will endeavour to make their way into the hive. Observe them by moonlight, and you will see the sentinels pacing about with their antennæ extended, and alternately directed to the right and left. In the mean time the moths flutter round the entrance; and it is curious to see with what art they know how to profit of the disadvantage that the bees, which cannot discern objects but in a strong light, labour under at that time. But should they touch a moth with these organs of nice sensation, it falls an immediate victim to their just anger. The moth, however, seeks to glide between the sentinels, avoiding with the utmost caution, as if she were sensible that her safety depended upon it, all contact with their antennæ. These bees upon guard in the night, are frequently heard to utter a very short low hum; but no sooner does any strange insect or enemy touch their antennæ, than the guard is put into a commotion, and the hum becomes louder, resembling that of bees when they fly, and the enemy is assailed by workers from the interior of the hive[b].

To defend themselves from the death's-head hawk-moth, they have recourse to a different proceeding. In seasons in which they are annoyed by this animal, they

[a] Vol. I. 4th Ed. 164.

[b] Huber, *Nouv. Obs.* ii. 412.

often barricade the entrance of their hive by a thick wall made of wax and propolis. This wall is built immediately behind and sometimes in the gateway, which it entirely stops up; but it is itself pierced with an opening or two sufficient for the passage of one or two workers. These fortifications are occasionally varied: sometimes there is only one wall, as just described, the apertures of which are in arcades, and placed in the upper part of the masonry. At others many little bastions, one behind the other, are erected. Gateways masked by the anterior walls, and not corresponding with those in them, are made in the second line of building. These casemated gates are not constructed by the bees without the most urgent necessity. When their danger is present and pressing, and they are as it were compelled to seek some preservative, they have recourse to this mode of defence[a], which places the instinct of these animals in a wonderful light, and shows how well they know how to adapt their proceedings to circumstances. Can this be merely sensitive? When attacked by strange bees, they have recourse to a similar manœuvre; only in this case they make but narrow apertures, sufficient for a single bee to pass through.—Pliny affirms that a sick bear will provoke a hive of bees to attack him in order to let him blood[b]. What will you say, if humble-bees have recourse to a similar manœuvre? It is related to me by Dr. Leach, from the communications of Mr. Daniel Bydder—an indefatigable and well-informed collector of insects, and observer of their proceedings—that *Apis ter-*

[a] Huber, *Nouv. Obs.* ii. 294— [b] *Hist. Nat.* l. viii. c. 36.

restris, when labouring under *Acariasis*[a] from the numbers of a small mite (*Gammasus Gymnopterorum*, F.) that infest it, will take its station in an ant-hill; where beginning to scratch, and kick, and make a disturbance, the ants immediately come out to attack it, and falling foul of the mites, they destroy or carry them all off; when the bee, thus delivered from its enemies, takes its flight.

In this long detail, the first idea that will, I should hope, strike the mind of every thinking being, is the truth of the Psalmist's observation—that the tender mercies of God are over all his works. Not the least and most insignificant of his creatures is, we see, deprived of his paternal care and attention; none are exiled from his all-directing providence. Why then should man, the head of the visible creation, for whom all the inferior animals were created and endowed; for whose well-being, in some sense, all these wonderful creatures with their miraculous instincts, whose history I am giving you, were put in action,—why should he ever doubt, if he uses his powers and faculties rightly, that his Creator will provide him with what is necessary for his present state?—Why should he imagine that a Being, whose very essence is LOVE, unless he compels him by his own wilful and obdurate wickedness, will ever cut him off from his care and providence?

Another idea that upon this occasion must force itself into our mind is, that nothing is made in vain. When we find that so many seemingly trivial variations in the colour, clothing, form, structure, motions, habits, and

[a] VOL. I. 4th Ed. 97—

economy of insects are of very great importance to them, we may safely conclude that the peculiarities in all these respects, of which we do not yet know the use, are equally necessary: and we may almost say, reversing the words of our Saviour, that not a *hair* is given to them without our Heavenly Father.

I am, &c.

LETTER XXII.

MOTIONS OF INSECTS. (*Larva and Pupa.*)

AMONGST the means of defence to which insects have recourse, I have noticed their *motions*. These shall be the subject of the present letter. I shall not, however, confine myself to those by which they seek to escape from their enemies; but take a larger and more comprehensive survey of them, including not only every species of locomotion, but also the movements they give to different parts of their body when in a state of repose: and in order to render this survey more complete, I shall add to it some account of the various organs and instruments by which they move.

Whenever you go abroad in summer, wherever you turn your eyes and attention, you will see insects in motion. They are flying or sailing everywhere in the air; dancing in the sun or in the shade; creeping slowly, or marching soberly, or running swiftly, or jumping upon the ground; traversing your path in all directions; coursing over the surface of the waters, or swimming at every depth beneath; emerging from a subterranean habitation, or going into one; climbing up the trees, or de-

scending from them; glancing from flower to flower; now alighting upon the earth and waters, and now leaving them to follow the impulse of their various instincts; sometimes travelling singly; at other times in countless swarms: these the busy children of the day, and those of the night. If you return to your apartment—there are these ubiquitaries—some flying about—others pacing against gravity up the walls or upon the cieling—others walking with ease upon the glass of your windows, and some even venturing to take their station on your own sacred person, and asserting their right to the lord of the creation.

This universal movement and action of these restless little animals gives life to every part and portion of our globe, rendering even the most arid desert interesting. From their visitations every leaf and flower becomes animated; the very dust seems to quicken into life, and the stones, like those thrown by Deucalion and Pyrrha, to be metamorphosed into locomotive beings. In the variety of motions which they exhibit, we see, as Cuvier remarks[a], those of every other description of animals. They walk, run, and jump with the quadrupeds; they fly with the birds; they glide with the serpents; and they swim with the fish. And the provision made for these motions in the structure of their bodies is most wonderful and various. "If I was minded to expatiate," says the excellent Derham, "I might take notice of the admirable mechanism in those that creep; the curious oars in those amphibious insects that swim and walk; the incomparable provision made in the feet of such as walk

[a] *Anatom. Compar.* i. 444.

or hang upon smooth surfaces; the great strength and spring in the legs of such as leap; the strong-made feet and talons of such as dig; and, to name no more, the admirable faculty of such as cannot fly, to convey themselves with speed and safety, by the help of their webs, or some other artifice, to make their bodies lighter than the air[a]."

Since the motions, and instruments of motion, of insects are usually very different in their preparatory states, from what they are in the imago or perfect state, I shall therefore consider them separately, and divide my subject into—motions of larvæ,—motions of pupæ,—and motions of perfect insects.

I. Amongst *larvæ* there are two classes of movers—*Apodous* larvæ, or those that move without legs,—and *Pedate* larvæ, or those that move by means of legs. I must here observe, that by the term *legs*, which I use strictly, I mean only jointed organs, that have free motion, and can walk or step alternately; not those spurious legs without joints, that have no free motion, and cannot walk or take alternate steps; such as support the middle and anus of the larvæ of most *Lepidoptera* and saw-flies (*Tenthredinidæ*).

Apodous larvæ seldom have occasion to take long journeys; and many of them, except when about to assume the pupa, only want to change their place or posture, and to follow their food in the substance, whether animal or vegetable, to which, when included in the egg, the parent insect committed them. Legs therefore would be

[a] *Physico-Theol.* Ed. 13. 363.

of no great use to them, and to these last a considerable impediment. They are capable of three kinds of motion;—they either walk, or jump, or swim. I use *walking* in an improper sense, for want of a better term equally comprehensive: for some may be said to move by gliding; and others (I mean those that, fixing the head to any point, bring the tail up to it, and so proceed) by stepping.

The motion of serpents was ascribed by some of the ancients (who were unable to conceive that it could be effected naturally, unless by the aid of legs, wings, or fins,) to a preternatural cause. It was supposed to resemble the "*incessus deorum*," and procured to these animals, amongst other causes, one of the highest and most honourable ranks in the emblematical class of their false divinities [a]. Had they known Sir Joseph Banks's late discovery,—that some serpents push themselves along by the points of their ribs, which Sir E. Home has found to be curiously constructed for this purpose,—their wonder would have been diminished, and their serpent-gods undeified. But though serpents can no longer make good their claim to motion *more deorum*, some insects may take their places; for there are numbers of larvæ, that having neither legs, nor ribs, nor any other points by which they can push themselves forward on a plane, *glide* along by the alternate contraction and extension of the segments of their body. Had the ancient Egyptians been aware of this, their catalogue of insect divinities would have been wofully crowded. In this annular motion, the animal alternately

[a] *Encycl. Brit.*, art. *Physiology*, 709.

supports each segment of the body upon the plane of position, which it is enabled to do by the little bundles of muscles attached to the skin, that take their origin within the body[a].

I shall begin the list of *walkers*, the movements of which are aided by various instruments, with one which is well known to most people,—the grub of the nut-weevil (*Curculio Nucum*, L.). When placed upon a table, after lying some time, perhaps, bent in a bow, with its head touching its tail, at last it begins to move, which, though in no certain direction, it does with more speed than might be expected. Rösel fancied that this animal had feet furnished with claws; but in this, as De Geer justly observes, he was altogether mistaken, since it has not the least rudiment of them, its motion being produced solely by the alternate contraction and extension of the segments of the body, assisted, perhaps, by the fleshy prominences of its sides—Other larvæ have this annular motion aided by a slimy secretion, which gives them further hold upon the plane on which they are moving, and supplies in some degree the place of legs or claws. That of the weevil of the common fig-wort (*Cionus Scrophulariæ*, Latr.) is always covered with slime, which enables it,—though it renders its appearance disgusting,—to walk with steadiness, by the mere lengthening and shortening of its segments, upon the leaves of that plant[b].—Of this kind also are those larvæ, mentioned above[c], received by De Geer from M. Ziervogel, which, adhering to each other by a slimy secre-

[a] Cuvier, *Anat. Comp.* i. 430. [b] De Geer, v. 210.
[c] See above, p. 7.

tion, glide along so slowly upon the ground as to be a quarter of an hour in going the breadth of the hand whence the natives call their bands *Gårds-drag*[a].

As a further help, others again call in the assistance of their unguiform mandibles. These, which are peculiar to grubs with a variable membranaceous head, especially those of the fly tribe (*Muscidæ*), when the animal does not use them, are retracted not only within the head, but even within the segments behind it[b]; but when it is moving they are protruded, and lay hold of the surface on which it is placed. They were long ago noticed by the accurate Ray. "This blackness in the head," says he, speaking of the maggot of the common flesh-fly, "is caused by two black spines or hooks, which when in motion it puts forth, and fixing them in the ground, so drags along its body[c]."—The larvæ of the aphidivorous flies (*Syrphus*, F.), the ravages of which amongst the Aphides I have before described to you[d], transport themselves from place to place in the same way, walking by means of their teeth. Fixing their hind part to the substances on which they are moving, they give their body its greatest possible tension; and, if I may so speak, thus take as long a step as they can: next, laying hold of it with their mandibles, by setting free the tail and relaxing the tension, the former is brought near the head. Thus the animal proceeds, and thus will even walk upon glass[e]. Some grubs, as the lesser house-fly (*Musca domestica minor*, De Geer), have only one of these claw-teeth; and in

[a] De Geer, vi. 338. [b] Ibid. vi. 65. [c] *Hist. Ins.* 270.
[d] Vol. I. 4th Ed. 264. [e] Reaumur, iii. 369.

some they have the form as well as the office of legs[a]. Bonnet mentions an apodous larva, that, before it can use its mandibles, is obliged to spin, at certain intervals, little hillocks or steps of silk; of which it then lays hold by them, and so drags itself along.

Besides their mandibular hooks, some of these grubs supply the want of legs by means of claws at their anus. Thus that of the flesh-fly, Ray tells us in the place just quoted, pushes itself by the protruded spines of its tail. The larva also of a long-legged gnat (*Tipula replicata*, L.), which in that state lives in the water, is furnished with these anal claws, which, in conjunction with its annular tension and relaxation, and the hooks of its mouth, assist it in walking over the aquatic plants[b].

A remarkable difference, according to their station, obtains in the bots of gad-flies; those that are subcutaneous (*Cuticolæ*, Clark) having no unguiform mandibles; while those that are gastric (*Gastricolæ*, Clark), and those that inhabit the maxillary sinuses of animals (*Cavicolæ*, Clark), are furnished with them. In this we evidently see Creative Wisdom adapting means to their end. For the cuticular bots having no plane surface to move upon, and imbibing a liquid food, in them the mandibular hooks would be superfluous. But they are furnished with other means by which they can accomplish such motions, and in contrary directions, as are necessary to them; the anterior part of each segment being beset with numbers of very minute spines, not visible except under a strong magnifier, sometimes ar-

[a] Vol. I. 2d Ed. 138. De Geer, vi. 76. Reaumur, iv. 376. Swamm. *Bibl. Nat.* Ed. Hill, ii. 46. a. *t.* xxxix. *f.* 3, *h. h.*

[b] De Geer, vi. 355.

ranged in bundles, which all look towards the anus; and the posterior part is as it were paved with similar hooks, but smaller, which point to the head. Thus we may conceive, when the animal wants to move forward, that it pushes itself by the first set of hooks, keeping the rest, which would otherwise impede motion in that direction, pressed close to its skin—or it may depress that part of the segment; and when it would move backwards that it employs the second[a]. The other descriptions of bots, not being embedded in the flesh but fixed to a plane, are armed with the mandibles in question, by which they can not only suspend themselves in their several stations, but likewise, with the aid of the spines with which their segments also are furnished, move at their pleasure[b]. Other larvæ of flies, as well as the bots, are furnished with spines or hooks—by which they take stronger hold—to assist them in their motions. Those mentioned in my last letter as inhabiting the nests of humble-bees[c], besides the six radii that arm their anus, and which perhaps may assist them in locomotion, have the margin of their body fringed with a double row of short spines[d], which are, doubtless, useful in the same way.

The next order of walkers amongst apodous larvæ are those that move by means of fleshy tuberculiform or pediform prominences,—which last resemble the spurious

[a] Reaum. iv. 416. *t.* xxxvi. *f.* 5. Compare Clark *On the Bots*, &c. 48.

[b] Mr. Clark (ibid. 62) observed only rough points on the bots of the sheep, but these also have spines or hooks looking towards the anus. Reaum. iv. 556. *t.* xxxv. *f.* 11, 13, 15. I also observed them myself in the same grub.

[c] See above, p. 223.

[d] PLATE XIX. FIG. 11.

legs of the caterpillars of most *Lepidoptera*. Some, a kind of monopods, have only one of such prominences, which being always fixed almost under the head, may serve, in some degree, the purpose of an unguiform mandible. The grub of a kind of gnat (*Tipula stercoraria*, De Geer), and also another, probably of the Tipulidan tribe (found by De Geer in a subputrescent stalk of Angelica which he was unable to trace to the fly), have each a fleshy leg on the underside of the first segment, which points towards the head and assists them in their motions[a].—Others again go a little further, and are supported at their anterior extremity by a pair of spurious legs. An aquatic larva of a most singular form, and of the same tribe, figured by Reaumur, is thus circumstanced. In this case the processes in question proceed from the head, and are armed with claws[b]. Would you think it—another Tipulidan grub is distinguished by *three* legs of this kind? It was first noticed by De Geer under the name of *Tipula maculata* (*Tanypus*, Meig.), who gives the following account of its motions and their organs:—It is found, he observes, in the water of swampy places and in ditches, is not bigger than a horse-hair, and about a quarter of an inch in length. Its mode of swimming is like that of a serpent, with an undulating motion of the body, and it sometimes walks at the bottom of the water and upon aquatic plants. The most remarkable part of it are its legs, called by Latreille, but it should seem improperly, tentacula. They resemble, by their length and rigidity,

[a] De Geer, vi. *t.* xxii. f. 15, *i. t.* xviii. f. 8, *p.*
[b] Reaum, v. *t.* vi. f. 5, *mm.*

wooden legs. The anterior leg is attached to the underside, but towards the head, of the first segment of the body. It is long and cylindrical, placed perpendicularly or obliquely, according to the different movements the animal gives it, and terminates in two feet, armed at their extremity by a coronet of long moveable hooks. These feet, like the tentacula of snails, are retractile within the leg, and even within the body, so that only a little stump, as it were, remains without. The insect moves them both together, as a lame man does his crutches, either backwards or forwards. The two posterior legs are placed at the anal end of the body. They are similar to the one just described, but larger, and entirely separate from each other, being not, like them, retractile within the body, but always stiff and extended. These also are armed with hooks. In walking, this larva uses these two legs much as the caterpillars of the moths, called *Geometræ*, do theirs. By the inflection of the anus it can give them any kind of lateral movement, except that it can neither bend nor shorten them, since like a wooden leg, as I have before observed, they always remain stiff and extended[a]. Lyonet had observed this larva, or a species nearly related to it; but he speaks of it as having four legs, two before and two behind. Probably, when he examined them, the common base, from which the feet are branches, was retracted within the body[b].

Generally speaking, however, in these apodous walkers the place of legs is supplied by fleshy and often retractile mamillæ or tubercles. By means of these and a

[a] De Geer, vi. 395—. Plate XXIII. Fig. 7. Foreleg, *a*. Hind-legs, *bb*. [b] Lesser *L*. i. 96. note †.

slimy secretion, unaided by mandibular hooks, the caterpillar of a little moth (*Hepialus Testudo*, F. *Apoda*, Haworth) moves from place to place[a].—A subcutaneous larva belonging to the same order, that mines the leaves of the rose, moves also by tubercular legs assisted by slime. It has eighteen homogeneous legs, with which, when removed from its house of concealment, it will walk well upon any surface, whether horizontal, inclined, or even vertical[b]. But the greatest number of legs of this kind that distinguish any known larva, is to be observed in that of a two-winged fly (*Scæva Pyrastri*, F.) that devours the Aphides of the rose. This animal has six rows of tubercular feet, with which it moves, each row consisting of seven, making in all forty-two[c].—The grub of the weevil of the dock (*Curculio Rumicis*, L.) has twenty-four tubercular legs; but, what is remarkable, the six anterior ones, being longer than the rest, seem to represent the real legs, while the others represent the spurious ones, of lepidopterous larvæ. These legs, however, are all fleshy tubercles, and have no claws, the place of which is supplied by slime which covers all the underside of the body, and hinders the animal from falling[d]. Another weevil (*Lixus paraplecticus*, F.) produces a grub inhabiting the water-hemlock, which has only six tubercles that occupy the place and are representatives of the legs of the perfect insect[e].

Some larvæ have these tubercles armed with claws. The maggot of a fly described by De Geer under the name of *Musca plumata*, but which Linné makes a variety of *Syrphus mystaceus*, F., has six pair of them, each

[a] Klemann, *Beitrage*, 324. [b] De Geer, i. 447—. *t.* xxxi. *f.* 17.
[c] De Geer, vi. 111. [d] Ibid. v. 233. [e] Ibid. 228.

of which has three long claws. This animal has a radiated anus, and seems related to those flies that live in the nests of humble-bees[a].

Insects in the peculiarities of their structure, as we have seen in many instances, sometimes realize the wildest fictions of the imagination. Should a traveller tell you that he had seen a quadruped whose legs were on its back, you would immediately conclude that he was playing upon your credulity, and had lost that regard to truth which ought to distinguish the narratives of persons of his description. What then will you say to me, when I affirm, upon the evidence of two most unexceptionable witnesses, Reaumur and De Geer, that there are insects which exhibit this extraordinary structure? The grub of a little gall-fly, appearing to be *Cynips Quercus inferus* of Linné—which inhabits a ligneous gall resembling a berry to be met with on the underside of oak-leaves—was found by the former to have on its back, on the middle of each segment, a retractile fleshy protuberance that resembled strikingly the spurious legs of some caterpillars. A little attention will convince any one, argues Reaumur, that the legs of insects circumstanced like the one under consideration, if it has any, should be on its back. For this grub—inhabiting a spherical cavity, in which it lies rolled up as it were in a ring—when it wants to move, will be enabled to do so, in this hollow sphere, with much more facility, by means of legs on the middle of its back, than if they were in their ordinary situation[b]. So wisely has Providence ordered every thing.—Another similar instance is recorded

[a] De Geer, vi. 137. *t.* viii. *f.* 8, 9. [b] Reaum. iii. 496. *t.* xlv. *f.* 3.

by De Geer, which indeed had previously been noticed, though cursorily, by the illustrious Frenchman[a]. There is a little larva, he observes, to be found at all seasons of the year, the depth of winter excepted, in stagnant waters, which keeps its body always doubled as it were in two, against the sides of ditches or the stalks of aquatic plants. If it is placed in a glass half full of water, it so fixes itself against the sides of it, that its head and tail are in the water while the remainder of the body is out of it; thus assuming the form of a siphon, the tail end being the longest. When this animal is disposed to feed, it lifts its head and places it horizontally on the surface of the water, so that it forms a right angle with the rest of the body, which always remains in a situation perpendicular to the surface. It then agitates, with vivacity, a couple of brushes, formed of hairs and fixed in the anterior part of the head, which producing a current towards the mouth, it makes its meal of the various species of animalcula, abounding in stagnant waters, that come within the vortex thus produced. As these animals require to be firmly fixed to the substance on which they take their station, and their back is the only part, when they are doubled as just described, that can apply to it,—they are furnished with minute legs armed with black claws, by which they are enabled to adhere to it. They have ten of these legs: the four anterior ones, which point towards the head and are distant from each other, are placed upon the fourth and fifth dorsal segments of the body; and the six posterior ones, which point to the anus and are so near to each other as at first

[a] Reaum. *Mem. de l'Acad. Roy. des Sciences de Paris*, An. 1714. p. 203.

to look like one leg, are placed on the eighth, ninth, and tenth. When the animal moves, the body continues bent, and the sixth segment, which is without feet and forms the summit of the curve, goes first[a]. De Geer named the fly it produces *Tipula amphibia*: it seems not clear, from his figure, to which of the modern genera of the *Tipulidæ* it belongs.

I come now to the jumping apodes, and one of this description will immediately occur to your recollection,—that I mean which revels in our richest cheeses, and produces a little black shining fly (*Tephritis putris*, F.). These maggots have long been celebrated for their saltatorious powers. They effect their tremendous leaps—laugh not at the term, for they are truly so when compared with what human force and agility can accomplish—in nearly the same manner as salmon are stated to do when they wish to pass over a cataract, by taking their tail in their mouth, and letting it go suddenly. When it prepares to leap, our larva first erects itself upon its anus, and then, bending itself into a circle by bringing its head to its tail, it pushes forth its unguiform mandibles, and fixes them in two cavities in its anal tubercles. All being thus prepared, it next contracts its body into an oblong, so that the two halves are parallel to each other. This done, it lets go its hold with so violent a jerk that the sound produced by its mandibles may be readily heard, and the leap takes place. Swammerdam saw one, whose length did not exceed the fourth part of an inch, jump in this manner out of a box six inches deep; which is as if a man six feet high should

[a] De Geer, vi. 380—*t.* xxiv. *f.* 1-9.

raise himself in the air by jumping 144 feet! He had seen others leap a great deal higher[a]. The grub of a little gnat lately noticed (*Tipula stercoraria*, De Geer) has a similar faculty, though executed in a manner rather different. These larvæ, which inhabit horse-dung, though deprived of feet, cannot move by annular contraction and dilatation; but are able, by various serpentine contortions, aided by their mandibles, to move in the substance which constitutes their food. Should any accident remove them from it, Providence has enabled them to recover their natural station by the power I am speaking of. When about to leap, they do not, like the cheese-fly, erect themselves so as to form an angle with the plane of position; but lying horizontally, they bring the anus near the head, regulating the distance by the length of the leap they mean to take; when fixing it firmly, and then suddenly resuming a rectilinear position, they are carried through the air sometimes to the distance of two or three inches. They appear to have the power of flattening their anal extremity, and even of rendering it concave: by means of which it may probably act as a sucker, and so be more firmly fixable[b].—The grub of a fly whose proceedings in that state I have before noticed[c] (*Leptis Vermileo*, F.), will, when removed from its habitation, endeavour to recover it by leaping. Indeed this mode of motion seems often to be given to this description of larvæ by Providence, to enable them to return to their natural station, when by any accident they have wandered away from it.

Many apodous larvæ inhabit the water, and therefore

[a] Swamm. *Bibl. Nat.* Ed. Hill, ii. 64. b. [b] De Geer, vi. 389—
[c] Vol. I. 4th Ed. 432.

must be furnished with means of locomotion proper to that element. To this class belongs the common gnat (*Culex pipiens*, L.), which being one of our greatest torments, compels us to feel some curiosity about its history. Its larva is a very singular creature, furnished with a remarkable anal apparatus for respiration, by which it usually remains suspended at the surface of the water. If disposed to descend, it seems to sink by the weight of its body; but when it would move upwards again, it effects its purpose by alternate contortions of the upper and lower halves of it, and thus it moves with much celerity. The laminæ or swimmers, which terminate its anus[a], are doubtless of use to it in promoting this purpose. It does not, that I ever observed, move in a lateral direction, but only from the surface downwards, and *vice versa*.—Another dipterous larva (*Corethra culiciformis*, Meig.) which much resembles that of the gnat in form, differs from it in its motions and station of repose. For, instead of being suspended at the surface with its head downwards, it usually, like fishes, remains in a horizontal position in the middle of the water. When it ascends to the surface, it is always by means of a few strokes of its tail, so that its motion is not equable, *sed per saltus*. It descends again gradually by its own weight, and regains its equilibrium by a single stroke of the tail[b].—A well known fly (*Stratyomis Chamæleon*, F.), in its first state an aquatic animal, often remains suspended, by its radiated anus, at the surface of the water, with its head downwards. But when it is disposed to seek the bottom or to descend, by bending the radii of

[a] Reaum. iv. *t.* 43. *f.* 3. *nn.* [b] De Geer, vi. 375. *t.* xxiii. *f.* 4, 5.

its tail so as to form a concavity, it includes in them a bubble of air, in brilliancy resembling silver or pearl; and then sinks with it by its own weight. When it would return to the surface it is by means of this bubble, which is, as it were, its air-balloon. If it moves upon the surface or horizontally, it bends its body alternately to the right and left, contracting itself into the form of the letter S; and then extending itself again into a straight line, by these alternate movements it makes its way slowly in the water[a].

I have dwelt longer upon the apodous larvæ, or those that are without what may be called proper legs, analogous to those of perfect insects, because the absence of these ordinary instruments of motion is in numbers of them supplied in a way so remarkable and so worthy to be known; and because in them the wisdom of the Creator is so conspicuously, or, I should rather say, so strikingly manifested—since it is doubtless equally conspicuous in the ordinary routine of nature. But aberrations from her general laws, and modes, and instruments of action, often of rare occurrence, impress us more forcibly than any thing that falls under our daily observation.

I come now to *pedate* larvæ, or those that move by means of proper or articulate legs. These legs (generally six in number, and attached to the underside of the three first segments of the body) vary in larvæ of the different orders: but they seem in most to have joints answering to the hip (*coxa*); trochanter; thigh (*femur*);

[a] Swamm. *Bibl. Nat.* Ed. Hill, ii. 44. b. 47. a.

shank (*tibia*); foot (*tarsus*), of perfect insects, the legs of which they include. Cuvier, speaking of *Coleoptera* and some *Neuroptera*, mentions only three joints. But many in these orders (amongst which he included the *Trichoptera*) have the joints I have enumerated. To name no more, the *Scarabæidæ*, *Dytisci*, *Silphæ*, *Staphylini*, *Cicindelæ*, and *Gyrini*, amongst coleopterous larvæ; and the *Phryganeæ*, as well as the *Libellulidæ* and *Ephemeræ*, amongst Cuvier's *Neuroptera*,—have these joints, and in many the last terminates in a double claw [a]. In some coleopterous genera the tarsus seems absent or obsolete. The larva of the lady-bird (*Coccinella*) affords an example of the former kind, and that of *Chrysomela* of the latter [b]. These joints are very visible in the legs of caterpillars of *Lepidoptera*, and their tarsus is armed with a single claw [c]. The larvæ that have these legs walk with them sometimes very swiftly. In stepping they set forward at the same time the anterior and posterior legs of one side, and the intermediate one of the other; and so alternately on each side.

Pedate larvæ are of two descriptions: those that to perfect legs add spurious ones with or without claws, and those that have only perfect legs. I begin with the former—those that have both kinds of legs. But first I must make a few remarks upon *spurious* legs. Because their muscles, instead of the horny substance that protects them in perfect legs, are covered only by a soft membrane, they have been usually denominated *membrana-*

[a] For examples of larvæ having these joints, see De Geer, iv. 289. *t.* xiii. *f.* 20. *t.* xv. *f.* 14. ii. *t.* xii. *f.* 3. *t.* xvi. *f.* 5, 6. *t.* xix. *f.* 4. &c.

[b] Ibid. v. *t.* xi. *f.* 11. *t.* ix. *f.* 9, o.

[c] Lyonet, *Traité Anatom.* *t.* iii. *f.* 8.

ceous legs: since, however, they are temporary, vanishing altogether when the insect arrives at its perfect state,—are merely used, for they do not otherwise assist in this motion, as props to hinder its long body, when it walks, from trailing on the ground; to push against the plane of position; and, by means of their hooks or claws, to fix itself firmly to its station when it feeds or reposes,—I shall therefore call them prolegs (*propedes*). These organs consist of three or four folds, and are commonly terminated, though not always, by a coronet or semicoronet of very minute crooked claws or hooks. These claws, which sometimes amount to nearly a hundred on one proleg, are alternately longer and shorter. They are crooked at both ends, and are attached to the proleg by the back by means of a membrane, which covers about two-thirds of their length, leaving their two extremities naked. Of these the upper one is sharp, and the lower blunt. The sole, or part of the prolegs within the claws, is capable of opening and shutting. When the animal walks, that they may not impede its motion, it is shut, and the claws are laid flat with their points inwards; but when it wishes to fix itself, the sole is opened, becoming of greater diameter than before, and the claws stand erect with their points outwards. Thus they can lay stronger hold of the plane of position[a].

The number of these prolegs varies in different species and families. In the numerous tribes of saw-flies (*Tenthredo*, L.), the larvæ of which resemble those of *Lepidoptera*, and are called by Reaumur spurious caterpillars (*fausses chenilles*), one family (*Cimbex*, F. *Lophy-*

[a] Lyonet, 82—*t*. iii. *f*. 10-16.

rus, Latr.) has sixteen prolegs; a second (*Hylotoma*, Latr. &c.) fourteen; another (*Tenthredo*, F.) twelve; and a fourth (*Lyda*, F.) none at all, having only the six perfect legs. The majority of larvæ of *Lepidoptera* have ten prolegs, eight being attached, a pair on each, to the sixth, seventh, eighth, and ninth segments of the body, and two to the twelfth or anal segment[a]. The caterpillar of the puss-moth (*P. Bombyx Vinula*, L.) and some others, instead of the anal prolegs, have two tails or horns. A hemigeometer, described by De Geer, has only six intermediate prolegs, the posterior pair of which are longer than the rest to assist the anal pair in supporting the body in a posture more or less erect[b]. Other hemigeometers, of which kind is the larva of *Noctua Gamma*, F.[c], have only six prolegs, four intermediate and two anal. The true geometers or surveyors (*Geometræ*) have only two intermediate and two anal prolegs. Many grubs of *Coleoptera*, especially those of *Staphylini*, *Silphæ*, &c., which are long and narrow, are furnished with a stiff joint at the anus, which they bend downwards and use as a prop to prevent their body from trailing. This joint, though without claws, may be regarded as a kind of proleg, which supports them when they walk[d]; and probably may assist their motion by pushing against the plane of position.

With respect to the larvæ that have only perfect legs, having just given you an account of these organs, I have nothing more to state relating to their structure. I shall therefore now consider the motions of pedate larvæ, un-

[a] Lyonet, *ubi supr. t.* 1. *f.* 4. [b] De Geer, i. 379. *t.* xxv. *f.* 1. 3.
[c] Vol. I. 4th Ed. 190, 191. [d] De Geer, i. 12. 40. *t.* i. *f.* 27. *q.* *t.* vi. *f.* 11. *e.*

der the several heads of walking or running, jumping climbing, and swimming.

Amongst those that *walk*, some are remarkable for the slowness of their motion, while others are extremely swift. The caterpillar of the hawk-moth of the Filipendula (*Zygæna Filipendulæ*, F.) is of the former description, moving in the most leisurely manner; while that of *Bombyx leporina*, F., a moth unknown in Britain, is named after the hare, from its great speed. The caterpillar of another moth, the species of which seems not to be ascertained, is celebrated by De Geer for the wonderful celerity of its motions. When touched it darts away backwards as well as forwards, giving its body an undulating motion with such force and rapidity, that it seems to fly from side to side[a].—Cuvier observes, that the grubs of some coleopterous and neuropterous insects, which have only the six perfect legs, by means of them lay hold of any surrounding object, and, fixing themselves to it, drag the rest of their body to that point; and that those of many capricorn beetles and their affinities (but that of *Callidium violaceum* is an apode[b]) have these legs excessively minute and almost nothing; that they move in the sinuosities which they bore by the assistance of their mandibles, with which they fix themselves, and also of several dorsal and ventral tubercles, by which they are supported against the sides of their cavity, and push themselves along, in the same manner as a chimney-sweeper—by the pressure of his knees, elbows, shoulder-blades, and other prominent parts—pushes himself up a chimney[c]. The larva

[a] De Geer, i. 424. [b] Kirby in *Linn. Trans.* v. 258.
[c] *Anatom. Comp.* i. 430.

of the ant-lion (*Myrmeleon*)—with the exception of one species, which moves in the common way—always walks backwards, even when its legs are cut off.

The *jumpers* amongst pedate larvæ, as far as they are known, are not very numerous, and will not detain you long. When the caterpillar of *Noctua Quadra*, F., a moth not uncommon, would descend from one branch or leap to another, it approaches to the edge of the leaf on which it is stationed, bends its body together, and retiring a little backwards, as if to take a good situation, leaps through the air, and, however high the jump, alights on its legs like a cat. That of another moth (*Pyralis rostralis*, F.) will also leap to a considerable height[a].

Another species of motion, which is peculiar to larvæ,—their mode I mean of *climbing*,—as it merits particular attention, will occupy more time. I have already related so many extraordinary facts in their history, that I promise myself you will not disbelieve me if I assert that insects either use ladders for this purpose, or a single rope. You may often have seen the caterpillar of the common cabbage-butterfly climbing up the walls of your house, and even over the glass of your windows. When next you witness this last circumstance, if you observe closely the square upon which the animal is travelling, you will find that, like a snail, it leaves a visible track behind it. Examine this with your microscope, and you will see that it consists of little silken threads, which it has spun in a zigzag direction, forming a rope-ladder, by which it ascends a surface it could not otherwise adhere to. The silk as it comes from the spinners

[a] Rösel, I. iv. 112. vi. 14.

is a gummy fluid, which hardens in the air; so that it has no difficulty in making it stick to the glass.—Many caterpillars that feed upon trees, particularly the geometers, have often occasion to descend from branch to branch, and sometimes, especially previously to assuming the pupa, to the ground. Had they to descend by the trunk, supposing them able to traverse with ease its rugged bark, what a circuitous route must they take before they could accomplish their purpose! Providence, ever watchful over the welfare of the most insignificant of its creatures, has gifted them with the means of attaining these ends, without all this labour and loss of time. From their own internal stores they can let down a rope, and prolong it indefinitely, which will enable them to travel where they please. Shake the branches of an oak or other tree in summer, and its inhabitants of this description, whether they were reposing, moving, or feeding, will immediately cast themselves from the leaves on which they were stationed; and however sudden your attack, they are nevertheless still provided for it, and will all descend by means of the silken cord just alluded to, and hang suspended in the air. Their name of geometer was given them, because they seem to measure the surface they pass over, as they walk, with a chain. If you place one upon your hand, you will find that they draw a thread as they go; when they move, their head is extended as far as they can reach with it; then fastening their thread there, and bringing up the rest of their body, they take another step; never moving without leaving this clue behind them; the object of which, however, is neither to measure, nor to mark its path that it may find it again; but

thus, whenever the caterpillar falls or would descend from a leaf, it has a cord always ready to support it in the air, by lengthening which it can with ease reach the ground. Thus it can drop itself without danger from the summit of the most lofty trees, and ascend again by the same road. As the silky matter is fluid when it issues from the spinners, it should seem as if the weight of the insect would be too great, and its descent too rapid, so as to cause it to fall with violence upon the earth. The little animal knows how to prevent such an accident, by descending gradually. It drops itself a foot or half a foot, or even less, at a time; then making a longer or shorter pause, as best suits it, it reaches the ground at last without a shock. From hence it appears that these larvæ have power to contract the orifice of the spinners, so as that no more of the silky gum shall issue from it; and to relax it again when they intend to resume their motion downwards: consequently there must be a muscular apparatus to enable them to effect this, or at least a kind of sphincter, which, pressing the silk, can prevent its exit. From hence also it appears, that the gummy fluid which forms the thread must have gained a degree of consistence even before it leaves the spinner, since as soon as it emerges it can support the weight of the caterpillar.—In ascending, the animal seizes the thread with its jaws as high as it can reach it; and then elevating that part of the back that corresponds with the six perfect legs, till these legs become higher than the head, with one of the last pair it catches the thread; from this the other receives it, and so a step is gained: and thus it proceeds till it has ascended to the point it wishes to reach. At this time if taken it will be

found to have a packet of thread, from which, however, it soon disengages itself, between the two last pairs of perfect legs[a]. To see hundreds of these little animals pendent at the same time from the boughs of a tree, suspended at different heights, some working their way downwards and some upwards, affords a very amusing spectacle. Sometimes, when the wind is high, they are blown to the distance of several yards from the tree, and yet maintain their threads unbroken. I witnessed an instance of this last summer, when numbers were driven far from the most extended branches, and looked as if they were floating in the air.

Having related to you what is peculiar in the motions of pedate larvæ upon the earth and in the air, I must next say something with respect to their locomotive powers in the *water*. Numbers of this description inhabit that element.—Amongst the beetles, the genera *Dytiscus*, *Hydrophilus*, *Gyrinus*, *Elmis*, *Parnus*, *Heterocerus*, *Elophorus*, *Hydræna*, &c. amongst the bug tribes (*Cimicidæ*), *Gerris*, *Velia*, *Hydrometra*, *Notonecta*, *Sigara*, *Nepa*, *Ranatra*, *Naucoris*; a few *Lepidoptera*; the majority of *Trichoptera*; *Libellula*, *Aeshna*, *Agrion*, *Sialis*, *Ephemera*, &c. amongst the *Neuroptera*; *Culex* and many of the *Tipulidæ* from the dipterous insects; and from the *Aptera*, *Atax*, some *Podurræ*, and many of the *Oniscidæ*, &c.—All these, in their larva state, are aquatic animals.

The motions of these creatures in this state are various. Some walk on the ground under water; some move in midwater, either by the same motion of the

[a] Reaum. ii. 375—

legs as they use in walking, or by strokes, as in swimming; others for this purpose employ certain laminæ, which terminate their tails, as oars; others again swim like fish, with an equable motion; some move by the force of the water which they spirt from their anus; others again swim about in cases, or crawl over the submerged bottom; and others walk even on the surface of the water. I shall not now enlarge on all these kinds of water-motion, since many will come under consideration hereafter.

There are two descriptions of larvæ of *Hydrophili*, one furnished with swimmers or anal appendages, by means of which they are enabled to swim; the other have them not, and hence are not able to rise from the bottom [a]. The larvæ of *Dytisci*, by means of these natatory organs, will swim, though slowly, and every now and then rise to the surface for the sake of respiration. Those of *Ephemeræ*, when they swim, apply their legs to the body, and swim with the swiftness and motions of fish [b]. Those of the true may-fly (*Semblis lutaria*, F.), on the contrary, use their legs in swimming, and at the same time, by alternate inflexions, give to their bodies the undulations of serpents [c]. But the larvæ of certain dragon-flies (*Aeshna* and *Libellula*, F.) will afford you the most amusement by their motions. These larvæ commonly swim very little, being generally found walking at the botton on aquatic plants: when necessary, however, they can swim well, though in a singular manner. If you see one swimming, you will find that the body is pushed forward by

[a] Miger, *Ann. du Mus.* xiv. 441. [b] De Geer, ii. 621.
[c] Ibid. 725—

strokes, between which an interval takes place. The legs are not employed in producing this progressive motion, for they are then applied close to the sides of the trunk, in a state of perfect inaction. But it is effected by a strong ejaculation of water from the anus. When I treat upon the respiration of insects, I shall explain to you the apparatus by which these animals separate the air from the water for that purpose; in the present case it is subsidiary to their motions, since it is by drawing in and then expelling the water that they are enabled to swim. To see this, you have only to put one of these larvæ into a plate with a little water. You will find that, while the animal moves forward, a current of water is produced by this pumping, in a contrary direction. As the larva, between every stroke of its internal piston, has to draw in a fresh supply of water, an interval must of course take place between the strokes. Sometimes it will lift its anus out of the water, when a long thread of water, if I may so speak, issues from it[a].

II. I am next to say something upon the motions of insects in their *pupa* state. This is usually to our little favourites a state of perfect repose; but, as I long since observed[b], there are several that, even when become pupæ, are as active and feed as rapaciously as they do when they are either larvæ or perfect insects. The *Dermaptera*, *Orthoptera*, *Hemiptera*, many of the *Neuroptera*, and the majority of the *Aptera*, are of this description. With respect to their motions, we may there-

[a] De Geer, ii. 675— Compare Reaum. vi. 393—
[b] Vol. I. 4th Ed. 66.

fore consider pupæ as of two kinds—*active* pupæ and *quiescent* pupæ.

The motions of most insects whose pupæ are *active*, are so similar in all their states, except where the wings are concerned, as not to need any separate account. I shall therefore request you to wait for what I have to say upon them, till I enter upon those of the imago. One insect, however, of this kind, moving differently in its preparatory states, is entitled to notice under the present head.—In a late letter, I mentioned to you a bug (*Reduvius personatus*, F.) which usually covers itself with a mask of dust, and fragments of various kinds, cutting a very grotesque figure[a]. Its awkward motions add not a little to the effect of its appearance. When so disposed, it can move as well and as fast as its congeners; yet this does not usually answer its purpose, which is to assume the appearance of an inanimate substance. It therefore hitches along in the most leisurely manner possible, as if it was counting its steps. Having set one foot forward (for it moves only one leg at a time), it stops a little before it brings up its fellow, and so on with the second and third legs. It moves its antennæ in a similar way, striking, as it were, first with one, and then, after an interval of repose, with the other[b].—The pupæ of gnats also, as well as those of many other aquatic *Diptera*, retain their locomotive powers, not however the free motion of their limbs. When not engaged in action, they ascend to the surface by the natural levity of their bodies, and are there suspended by two auriform respiratory organs in the anterior part of the trunk, their abdomen being then folded under the breast; when disposed to de-

[a] See above, p. 258. [b] De Geer, iii. 284.

scend the animal unfolds it, and by sudden strokes which she gives with it and her anal swimmers to the water, she swims, to the right and left as well as downwards, with as much ease as the larva[a].

Bonnet mentions a pupa which climbs up and down in its cocoon,—and that of the common glow-worm (*Lampyris noctiluca*, L.) will sometimes push itself along by the alternate extension and contraction of the segments of its body[b].—Others turn round when disturbed. That of a weevil (*Curculio Arator*, L.), which spins itself a beautiful cocoon like fine gauze, and which it fixes to the stalks of the common spurrey (*Sagina arvensis*, L.), upon my touching this stalk, whirled round several times with astonishing rapidity.—The chrysalis of a scarce moth (*Bombyx dispar*, F.) when touched turns round with great quickness; but, as if fearful of breaking the thread by which it is suspended by constantly twisting it in one direction, it performs its gyrations alternately from left to right, and from right to left[c]. Generally speaking, quiescent pupæ when disturbed show that they have life, by giving their abdomen violent contortions.

But the most extraordinary motion of pupæ is jumping. In the year 1810 I received an account from a very intelligent young lady, who collected and studied insects with more than common ardour and ability, that a friend had brought her a chrysalis endued with this faculty. It was scarcely a quarter of an inch in length; of an oval form; its colour was a semitransparent brown, with a white opake band round the middle. It was found

[a] De Geer, vi. 308. [b] Ibid. iv. 43.
[c] Dumeril, *Trait. Element.* ii. 49. n. 603.

attached, by one end, to the leaf of a bramble. It repeatedly jumped out of an open pill-box that was an inch in height. When put into a drawer in which some other insects were impaled, it skipped from side to side, passing over their backs for nearly a quarter of an hour with surprising agility. Its mode of springing seemed to be by balancing itself upon one extremity of its case. About the end of October one end of the case grew black, and from that time the motion ceased; and about the middle of April, in the following year, a very minute ichneumon made its appearance by a hole it had made at the opposite end.—Some time after I had received this history, I happened to have occasion to look at Reaumur's Memoir upon the enemies of caterpillars, where I met with an account of a similar jumping chrysalis, if not the same. Round the nests of the processionary Bombyx, before noticed[a], he found numerous little cocoons suspended by a thread three or four inches long to a twig or a leaf, of a shortened oval form, and close texture, but so as the meshes might be distinguished. These cocoons were rather transparent, of a coffee-brown colour, and surrounded in the middle by a whitish band. When put into boxes or glasses, or laid on the hand, they surprised him by leaping. Sometimes their leaps were not more than ten lines, at others they were extended to three or four inches, both in height and length. When the animal leaps, it suddenly changes its ordinary posture (in which the back is convex and touches the upper part of the cocoon, and the head and anus rest upon the lower), and strikes the upper part with the head and tail, before

[a] Vol. I. 4th Ed. 478; and above, p. 23.

its belly, which then becomes the convex part, touches the bottom. This occasions the cocoon to rise in the air to a height proportioned to the force of the blow. At first sight this faculty seems of no great use to an animal that is suspended in the air; but the winds may probably sometimes place it in a different and unsuitable position, and lodge it upon a leaf or twig: in this case it has it in its power to recover its natural station. Reaumur could not ascertain the fly that should legitimately come from this cocoon, for different cocoons gave different flies: whence it was evident that these ichneumons were infested by their own parasite[a]. This might be the case with that of the lady just mentioned. Perhaps, properly speaking, in this last instance the motions ought rather to be regarded as belonging to a larva; but as it had ceased feeding, and had inclosed itself in its cocoon, I consider it as belonging to the present head.

You may probably here feel some curiosity to be informed how the numerous larvæ that are buried in their pupa state, either in the heart of trees, under the earth, or in the waters, effect their escape from their various prisons and become denizens of the air, especially as you are aware that each is shrowded in a winding sheet and cased in a coffin. In most, however, if you examine this coffin closely, you will see RESURGAM written upon it. What I mean is this. The *puparium* or case of the animal is furnished with certain acute points (*adminicula*) generally single, but in some instances forked, looking towards the anus, and usually placed upon transverse ridges on the back of the abdomen, but sometimes arming the sides or the margins of the

[a] Reaum. ii. 450.

segments. By this simple contrivance, aided by new-born vigour, when the time for its great change is arrived, the included prisoner of hope, if under ground, pushes itself gradually upwards, till reaching the surface its head and trunk emerge, when an opening in the latter being effected by its efforts, it escapes from its confinement, and once more tastes the sweets of liberty and the joys of life. Those that are inclosed in trees and spin a cocoon, are furnished with points on the head, with which they make an opening in the former. The pupa of the great goat-moth (*Bombyx Cossus*, F.) thus, by divers movements, keeps disengaging itself from this envelope, till it arrives at a hole in the tree which it had made when a caterpillar; when its anterior part having emerged, it stops short, and so escapes a fall that might destroy it. After some repose, in consequence of very violent efforts, the puparium opens, and it escapes from its prison[a].

The insects of the *Trichoptera* order (*Phryganea*, L.) are *quiescent* when they first assume the pupa, but become locomotive towards the close of their existence in that state. Since they inhabit the water when they become pupæ, Providence has furnished them with the means of quitting that fluid without injury, when they are to exchange it for the air; which in their winged state is their proper sphere of action. I have before described to you the grates which shut up their cases when they became quiescent[b]; if they had no means of piercing these grates, they would perish in the waters. The

[a] Lyonet, *Trait. Anat.* 15—

[b] See above, p. 264.

head of these pupæ is provided at first with a particular instrument, which enables them to effect this purpose. The anterior part of the head is armed with a pair of hooks in form resembling the beak of a bird; and with this, previously to their last change, they make an opening in the grate which, though it once defended, now confines them. But at this moment, perhaps, the insect has a considerable space of water to rise through before she can reach the surface. This is all wisely provided for; before she leaves the envelope which covers her body, she emerges from the water, and fixes herself upon some plant or other object, the summit of which is not overflowed. But you will here, perhaps, ask—How can a pupa in her envelope, with all her limbs set fast, do this? This affords another instance of the wise provision of the beneficent Father of the universe for the welfare of his creatures. The antennæ and legs of this tribe of insects, when they are pupæ, are not included, as is the case with most that are quiescent in that state, in the general envelope; but each in a separate one, so as to allow it free motion. Thus the insect when the time is come for its last change can use them (except the hind-legs, which being partly covered by the wing-cases remain without motion) with ease. It then stretches out its antennæ, and steering with its legs makes for the surface. De Geer saw one just escaped from its case run and swim with surprising agility over the bottom of a saucer, in which he had put some cases of these flies; and at last when he held a piece of stick to it, it got upon it, and having emerged from the water, prepared to cast its envelope. It is remarkable, that the envelope

of the intermediate tarsi, like the posterior ones of Dytisci, is fringed on one side with hairs, to enable the insects to use them as swimming feet[a], while those neither of the larva nor imago are so circumstanced.

I am, &c.

[a] De Geer, ii. 518—

LETTER XXIII.

MOTIONS OF INSECTS. (*Imago.*)

III. THE motions of insects in their perfect or *imago* state are various, and for various purposes; and the provision of organs by which they are enabled to effect them is equally diversified and wonderful. It will be convenient to divide this multifarious subject; I shall therefore consider their motions under two principal heads:—motions of insects *reposing*—and motions of insects *in action*;—and this last head I shall further subdivide into motions whose object is change of place, and sportive motions.

The first of these, motions of insects *reposing*, will not detain us long. The most remarkable is that of the long-legged gnats or crane-flies (*Tipulæ*, F.).—When at rest upon any wall or ceiling, sometimes standing upon four legs, and sometimes upon five, you may observe them elevate and depress their body alternately. This oscillating movement is produced by the weight of their body and the elasticity of their legs, and is constant and uninterrupted during their repose. Unless it

be connected with the respiration of the animal, it is not easy to say what is the object of it. Moths, when feeling the stimulus of desire, or under alarm, set their whole body into a tremor [a]. A living specimen of the hawk-moth of the willow being once brought me, upon placing it upon my hand, after ejecting a milky fluid from its anus, it put its wings and body into a most rapid vibration, which continued more than a minute, when it flew away. A butterfly, called by Aurelians "The large skipper," (*Hesperia Sylvanus*, F.) when it alights, which it does very often, for they are never long on the wing, always turns half-way round; so that, if it settles with its head from you, it turns it towards you.

Others of the motions in question are merely those of parts. Butterflies, when standing still in the sun, as you have doubtless often observed,

"Their golden pinions ope and close;"

thus, it should seem, unless this motion be connected with their respiration, alternately warming and cooling their bodies. You have probably noticed a very common little fly, of a shining black, with a black spot at the end of its wings (*Tephritis vibrans*, Latr., *Seioptera*, K. Ms.). It has received its trivial name (*vibrans*) from the constant vibration which, when reposing, it imparts to its wings. This motion also, I have reason to think, assists its respiration.—Some insects when awake are very active with their antennæ, though their bodies are at rest. I remember one evening attending for some time to the proceedings of one of those may-flies (*Phryganea*,

[a] Peck in *Linn. Trans.* xi. 92.

L.) that are remarkable, like certain moths, for their long antennæ. It was perched upon a blade of grass, and kept moving these organs, which were twice as long as itself, in all directions, as if by means of them it was exploring every thing that occurred in its vicinity.—Many Tipulæ, and likewise some mites (*Acarus vibrans* and *Gamasus motatorius*, F.), distinguished by long anterior legs, from this circumstance denominated *pedes motatorii* by Linné, holding them up in the air impart to them a vibratory motion, resembling that of the antennæ of some insects[a].—I scarcely need mention, what must often have attracted your attention, the actions of flies when they clean themselves; how busily they rub and wipe their head and thorax with their fore legs, and their wings and abdomen with their hind ones.—Perhaps you are not equally aware of the use to which the rove-beetles (*Staphylinus*, L.) put their long abdomen. They turn it over their back not only to put themselves in a threatening attitude, as I lately related[b], but also to fold up their wings with it, and pack them under their short elytra.

With respect to the motions of insects in *action*, they may be subdivided, as was just observed, into motions whose object is change of place—and sportive motions.

The *locomotions* of these animals are walking, running, jumping, climbing, flying, swimming, and burrowing. I begin with the *walkers*.

The mode of their *walking* depends upon the number and kind of their legs. With regard to these, insects may be divided into four natural classes; viz. *Hexapods*,

[a] De Geer, vi. 335.

[b] See above, p. 236.

or those that have only *six* legs: such are those of every order except the *Aptera* of Linné, of which only three or four genera belong to this class.—*Octopods*, or those that have *eight* legs, including the tribes of mites (*Acaridæ*); spiders (*Araneidæ*); long-legged spiders (*Phalangidæ*); and scorpions (*Scorpionidæ*):—*Polypods*, or those that have *fourteen* legs, consisting of the woodlouse tribe (*Oniscidæ*);—and *Myriapods*, or those that have more than fourteen legs—often more than a hundred—composed of the two tribes of centipedes (*Scolopendridæ*) and millepedes (*Julidæ*). The first of these classes may be denominated *proper*, and the rest *improper* insects. The legs of all seem to consist of the same general parts; the hip, trochanter, thigh, shank, and foot; the four first being usually without joints (though in the *Araneidæ* &c. the shank has two), and the foot having from one to above forty [a].

In *walking* and *running*, the hexapods, like the larvæ that have perfect legs, move the anterior and posterior leg of one side and the intermediate of the other alternately, as I have often witnessed. De Geer, however, affirms that they advance each pair of legs at the same

[a] The most common number of joints in the tarsus is from two to five; but the Phalangidæ have sometimes more than forty. In these, under a lens, this part looks like a jointed antenna.

Geoffroy, and after him most modern entomologists, has taken the *primary* divisions of the *Coleoptera* order from the number of joints in the tarsus; but this, although perhaps in the majority of cases it may afford a natural division, will not universally. For—not to mention the instance of *Pselaphus*, clearly belonging to the *Staphylinidæ*—both *Oxytelus*, Grav., and another genus that I have separated from it (*Carpalimus*, K. Ms.), have only two joints in their tarsi. In this tribe, therefore, it can only be used for secondary divisions. K.

time[b]; but this is contrary to fact, and indeed would make their ordinary motions, instead of walking and running, a kind of canter and gallop. Whether those that have more than six feet move in this way—which is not improbable—from the difficulty of attending at the same time to the movements of so many members, is not easily ascertained.

The dog-tick (*Ixodes Ricinus*, F.), if when young and active it moves in the same way that it does when swoln to an enormous size with blood, seems to afford an exception to the mode of walking just described. It first uses, says Ray, its two anterior legs as antennæ to feel out its way, and then fixing them, brings the next pair beyond them, which being also fixed, it takes a second step with the anterior, and so drags its bloated carcase along[b]. Redi observes, that when scorpions walk they use those remarkable comb-like processes at the base of their posterior legs to assist them in their motions, extending them and setting them out from the body, as if they were wings: and his observation is confirmed by Amoreux, who calls them ventral swimmers[c]. I have often noticed a millepede (*Julus terrestris*, L.), frequently found under the bark of trees, and where there is not a free circulation of air, the motions of which are worthy of attention. Observed at a little distance, it seems to glide over the surface, like a serpent, without legs; but a nearer inspection shows how its movement is accomplished. Alternate portions of its numerous legs are extended beyond the line of the body, so as to form an obtuse angle with it, while those in the intervals preserve

[a] iii. 284. [b] *Hist. Ins.* 10. [c] Redi *Opusc.* i. 80. Amoreux, 44—

a vertical direction. So that, as long as it keeps moving, little bunches of the legs are alternately in and out from one end to the other of its long body; and an amusing sight it is to see the undulating line of motion successively beginning at the head and passing off at the tail. —The motion of centipedes (*Scolopendra*), as well as that of this insect and its congeners, is retrogressive as well as progressive. Put your finger to the common one (*S. morsitans*, L.), and it will immediately retrograde, and with the same facility as if it was going forwards. This difference, however, is then observable—it uses its four hind legs, which, when it moves in the usual way, are dragged after it. Almost all the other apterous insects, as well as many of those in the other orders, can move in all directions; backwards, and towards both sides, as well as forwards. Bonnet mentions a spider (not a spinner) that always walked backwards when it attacked a large insect of its own tribe; but when it had succeeded in driving it from a captive fly, which however it did not eat, it walked forwards in the ordinary way[a].

Insects vary much in their walking paces: some crawling along; others walking slowly; and others moving with a very quick step. The field cricket (*Acheta campestris*, F.) creeps very slowly—the bloody-nose beetle (*Chrysomela tenebricosa*) and the oil-beetle (*Meloe Proscarabæus*) march very leisurely; the spider-wasps (*Pompilus*, F.) walk by starts, as it were, vibrating their wings, at the same time, without expanding them; while flies, ichneumons, wasps, &c., and many

[a] *Œuvr.* ii. 426.

beetles, walk as fast as they can. One insect, a kind of snake-fly (*Raphidia Mantispa*, F.), is said to walk upon its knees. The crane-flies (*Tipula oleracea*, L.) and shepherd-spiders, (*Phalangium*, L.) have legs so disproportionately long, that they seem to walk upon stilts; but when we consider that they have to walk over and amongst grass,—the former laying its eggs in meadows, —we shall see the reason of this conformation. Insects do not always walk in a right line; for I have often observed the little midges (*Psychoda*, Latr.), when walking up glass, moving alternately from right to left and from left to right, as humble-bees fly, so as to describe small zig-zags.

Numerous are the insects that *run*. Almost all the predaceous tribes, the black dors, clocks, or ground-beetles (*Carabidæ*), and their fellow destroyers the *Cicindelidæ*,—which last Linné, with much propriety, has denominated the tigers of the insect world,—are gifted with uncommon powers of motion, and run with great rapidity. The velocity, in this respect, of ants is also very great.—Mr. Delisle observed a fly—so minute as to be almost invisible—which ran nearly three inches in a demi-second, and in that space made 540 steps. Consequently it could take a thousand steps during one pulsation of the blood of a man in health[a]. Which is as if a man, whose steps measured two feet, should run at the incredible rate of more than twenty miles in a minute! How astonishing then are the powers with which these little beings are gifted!—The forest-fly (*Hippobosca*), and its kindred genus *Ornithomyia* parasitic upon birds, are extremely difficult to take, as I

[a] Lesser, *L.* i. 248, note 24.

have more than once experienced, from their extreme agility. I lost one from this circumstance two years ago that I found upon the sea-lark (*Charadrius Hiaticula*, L.) and which appeared to be non-descript. Another most singular insect, which though apterous is nearly related to these—I mean the louse of the bat (*Nycteribia Vespertilionis*, Latr.), is still more remarkabe for its swiftness. Its legs, as appears from the observations of Colonel Montague, are fixed in an unusual position on the upper side of the trunk. "It transports itself," to use the words of the gentleman just mentioned, "with such celerity, from one part of the animal it inhabits to the opposite and most distant, although obstructed by the extreme thickness of the fur, that it is not readily taken."——"When two or three were put into a small phial, their agility appeared inconceivably great; for, as their feet are incapable of fixing upon so smooth a body, their whole exertion was employed in laying hold of each other; and in this most curious struggle they appeared actually flying in circles: and when the bottle was reclined, they would frequently pass from one end to the other with astonishing velocity, accompanied by the same gyrations: if by accident they escaped each other, they very soon became motionless: and as quickly were the whole put in motion again by the least touch of the bottle, or the movement of an individual[a].—Incredibly great also is the rapidity with which a little reddish mite, with two black dots on the anterior part of its back (*Gamasus Baccarum*, F.), common upon strawberries, moves along.

[a] *Linn. Trans.* xi. 13.

Such is the velocity with which it runs, that it appears rather to glide or fly than to use its legs.

When insects walk or run, their legs are not the only members that are put in motion. They will not, or rather cannot, stir a step till their antennæ are removed from their station of repose and set in action. When the chafers (*Scarabæus*, L.) are about to move, these organs, before concealed, instantly appear, and the laminæ which terminate them being separated from each other as widely as possible, they begin their march. They employ their antennæ, however, not as feelers to explore surrounding objects,—their palpi being rather used for that purpose,—but, it should seem, merely to receive vibrations, or impressions from the atmosphere, to which these laminæ, especially in the male cockchafers (*Melolonthæ*, F.) present a considerable surface. Yet insects that have filiform or setaceous antennæ appear often to use them for exploring. When the turnip-beetle (*Haltica oleracea*, F.) walks, its antennæ are alternately elevated and depressed.—The same thing takes place with some woodlice (*Oniscidæ*), which use them as tactors, touching the surface on each side with them, as they go along. This is not however constantly the use of this kind of antennæ; for I have observed that *Telephorus lividus*,—a narrow beetle with soft elytra, common in flowers,—when it walks vibrates its setaceous antennæ very briskly, but does not explore the surface with them. The parasitic tribes of *Ichneumonidæ*, especially the minute ones, when they move vibrate these organs most intensely, and probably by them discover the insect to which the law of their nature ordains that they should commit their eggs; some even using them to explore the deep holes

in which a grub, the appropriate food of their larva, lurks[a]. But upon this subject I shall have occasion to enlarge when I treat of the senses of insects.—Antennæ are sometimes used as legs. A gnat-like kind of bug (*Gerris vagabundus*, F.) has very short anterior legs; or rather arms, while the two posterior pair are very long. Its antennæ also are long. When it walks, which it does very slowly, with a solemn measured step, its fore legs, which perhaps are useful only in climbing, or to seize its prey, are applied to the body, and the antennæ being bent, their extremity, which is rather thick, is made to rest upon the surface on which the animal moves, and so supply the place of fore legs[b].—I have observed that mites often use the long hairs with which the tail of some species is furnished, to assist them in walking.

Another mode of motion with which many insects are endowed is *jumping*. This is generally the result of the sudden unbending of the articulations of the posterior legs and other organs, which before had received more than their natural bend. This unbending impresses a violent rotatory motion upon these parts, the impulse of which being communicated to the centre of gravity, causes the animal to spring into the air with a determinate velocity, opposed to its weight more or less directly[c]. Various are the organs by which these creatures are enabled to effect this motion. The majority do it by a peculiar conformation of the hind legs; others, by a pectoral process; and others, again, by means of certain elastic appendages to the abdomen.

[a] Marsham in *Linn. Trans.* iii. 26— [b] De Geer, iii. 324—
[c] Cuvier, *Anat. Comp.* i. 496—

The *hind legs* of many beetles are furnished with remarkably large and thick posterior thighs. Of this description are several species of weevils (*Curculionidæ*); for instance, *Orchestes* Illig. and *Ramphus* Clairv.; the whole tribe of skippers (*Haltica*, F.), and the splendid African tribe of *Sagra*, F.[a], &c. The object of these disproportioned and clumsy thighs is to allow space for more powerful muscles, by which the tibiæ, when the legs are unbent, are impelled with greater force. In the *Orthoptera* order all the grasshoppers (*Gryllidæ*)—including the genera *Gryllotalpa*; *Acheta*; *Tridactylus*; *Gryllus*; *Locusta*; *Pneumora*; *Truxalis*; *Acrydium*; and *Tetrix* of Latreille—are distinguished by incrassated posterior thighs; which however are much longer, more tapering and shapely, (they are indeed somewhat clumsy in the two first genera, the crickets,) than those of most of the *Coleoptera* that are furnished with them. When disposed to leap, these insects bend their hind leg so as to bring the shank into close contact with the thigh—which has often a longitudinal furrow armed with a row of spines on each side, to receive it. The leg being thus bent, they suddenly unbend it with a jerk, when pushing against the plane of position, they spring into the air often to a considerable height and distance. A locust, which however is aided by its wings, it is said will leap two hundred times its own length[b].—Aristophanes, in order to make the great and good Athenian philosopher, Socrates, appear ridiculous, represents him as having measured the leap of a flea[c]. In our better times scientific men have done this without being

[a] Oliv. *Entom.* n. 90, *t.* i. [b] Swamm. *Bibl. Nat.* Ed. Hill, i. 123. b.
[c] Aristoph. *Nubes*, Act. i. Sc. 2.

laughed at for it, and have ascertained that, comparatively, it equalled that of the locust, being also two hundred times its length. Being affected by muscular force, without the aid of wings, this is an astonishing leap.—There are several insects, however, that, although they are furnished with incrassated posterior thighs, do not jump. Of this description are some beetles belonging to the genus *Necydalis*, (*Oedemera*, Oliv.) F., in which this seems a peculiarity of the male: and amongst the *Hymenoptera*, not to mention others, several species of *Chalcis*, F., and all that are known of that singular genus *Leucopsis*.

Many insects, that jump by means of their posterior legs, have not these thighs. This is said to be the case with *Scaphidium*, a little tribe of beetles[a]: and one of the same order, that seems to come between *Anobium* and *Ptilinus*, found by our friend the Rev. R. Sheppard, and which I have named after him *Choragus Sheppardi*, is similarly circumstanced.—In the various tribes of frog-hoppers (*Cicadiadæ*), the posterior tibiæ appear to be principally concerned in their leaping. These are often very long, and furnished, on their exterior margin, with a fringe of stiff hairs, or a series of strong spines, by pressing which against the plane of position they are supposed to be aided in effecting this motion. On this occasion they bend their legs like the grass-hoppers, and then unbending kick them out with violence[b]. Many of them, amongst the rest *Cicada spumaria*, have the extremity of the above tibiæ armed with a coronet of spines; these are of great use in pushing them off when

[a] Trost, *Beiträge*, 40. [b] De Geer, iii. 161.

the legs are unbended. This insect, when about to leap, places its posterior thighs in a direction perpendicular to the plane of position, keeping them close to the body; it next with great violence pushes them out backwards, so as to stretch the leg in a right line. These spines then lay hold of the surface, and by their pressure enable the body to spring forwards, when, being assisted by its wings, it will make astonishing leaps, sometimes as much as five or six feet, which is more than 250 times its own length; or as if a man of ordinary stature should be able at once to vault through the air to the distance of a quarter of a mile. Upon glass, where the spines are of no use, the insect cannot leap more than six inches[a].—The species of another genus of this order (*Chermes*, L.), that jump very nimbly by pushing out their shanks, are perhaps assisted in this motion by a remarkable horn looking towards the anus, which arms their posterior hip.—Some bugs that leap well, *Lygæus saltatorius*, F., &c., seem to have no particular apparatus to assist them, except that their posterior tibiæ are very long.—Several of the minute ichneumons also jump with great agility, but by what means I am unable to say.—There is a tribe of spiders, not spinners, that leap even sideways upon their prey. One of these (*Aranea scenica*, L., *Salticus*, Latr., *Attus*, Walck.), when about to do this, elevates itself upon its legs, and lifting its head seems to survey the spot before it jumps. When these insects spy a small gnat or fly upon a wall, they creep very gently towards it with short steps, till they come within a convenient distance, when they spring upon it

[a] De Geer, iii. 178.

suddenly like a tiger.—Bartram observed one of these spiders that jumped two feet upon a humble-bee. The most amusing account, however, of the motions of these animals is given by the celebrated Evelyn in his Travels. When at Rome, he often observed a spider of this kind hunting the flies which alighted upon a rail on which was its station. It kept crawling under the rail till it arrived at the part opposite to the fly, when stealing up it would attempt to leap upon it. If it discovered that it was not perfectly opposite, it would immediately slide down again unobserved, and at the next attempt would come directly upon the fly's back. Did the fly happen not to be within a leap, it would move towards it so softly, that its motion seemed not more perceptible than that of the shadow of the gnomon of a dial. If the intended prey moved, the spider would keep pace with it as exactly as if they were actuated by one spirit, moving backwards, forwards, or on each side without turning. When the fly took wing, and pitched itself behind the huntress, she turned round with the swiftness of thought, and always kept her head towards it, though to all appearance as immoveable as one of the nails driven into the wood on which was her station: till at last, being arrived within due distance, swift as lightning she made the fatal leap and secured her prey[a]. I have had an opportunity of observing very similar proceedings in *Salticus scenicus*, Latr.

But the legs of insects are not the only organs by which they leap. The numerous species of the elastic beetles (*Elater*, L.), skip-jacks as some call them, per-

[a] Evelyn, quoted in Hooke's *Microgr.* 200—

form this motion by means of a *pectoral process* or mucro. These animals having very short legs, when laid upon their backs, cannot by their means recover a prone position. To supply this seeming defect in their structure, Providence has furnished them with an instrument which, when they are so circumstanced, enables them to spring into the air and recover their standing. If you examine the breast (*pectus*) of one of these insects, you will observe between the base of the anterior pair of legs a short and rather blunt process, the point of which is towards the anus. Opposite to this point, and a little before the base of the intermediate legs, you will discover in the after-breast (*postpectus*) a rather deep cavity, in which the point is often sheathed. This simple apparatus is all that the insect wants to effect the above purpose. When laid upon its back, in your hand if you please, it will first bend back, so as to form a very obtuse angle with each other, the head and trunk, and abdomen and metathorax, by which motion the mucro is quite liberated from its sheath; and then bending them in a contrary direction, the mucro enters it again, and the former attitude being briskly and suddenly resumed, the mucro flies out with a spring, and the insect rising, sometimes an inch or two into the air, regains its legs and moves off. The upper part of the body, by its pressure against the plane of position, assists this motion, during which the legs are kept close to its underside. Cuvier, when he says that man and birds are the only animals that can leap vertically[a], seems to have forgotten this leap of Elaters, which is generally vertical, the trunk being vertically above the organ that produces the leap.

[a] *Anat. Comp.* i. 498.

Other insects again leap by means of the *abdomen* or some organs attached to it. An apterous species—belonging to the *Ichneumonidæ*, and to the genus *Cryptus*, F.—takes long leaps by first bending its abdomen inwards, as De Geer thinks, and then pushing it with force along the plane of position[a]. There is a tribe of minute insects amongst the *Aptera*, found often under bark, sometimes on the water, and in various other situations, which Linné has named *Podura*, a term implying that they have a leg in their tail. This is literally the fact. For the tail, or anal extremity, of these insects is furnished with an inflexed fork[b], which, though usually bent under the body, they have the power of unbending; during which action, the forked spring, pushing powerfully against the plane of position, enables the animal to leap sometimes two or three inches. What is more remarkable, these little animals are by this organ even empowered to leap upon water. There is a minute black species (*P. aquatica*, L.) which in the spring is often seen floating on that contained in ruts, hollows, or even ditches, and in such infinite numbers as to resemble gunpowder strewed upon the surface. When disturbed, these black grains are seen to skip about as if ignited, jumping with as much ease as if the fluid were a solid plane, that resists their pressure. The insects of another genus—separated from *Podura* by Latreille under the name of *Sminthurus*—have also an anal spring, which when bent under the body nearly reaches the head. These, which are of a more globose form than *Podura*, are so excessively agile that it is almost impossible to take them. Pressing their spring against the

[a] ii. 910. [b] PLATE XV. FIG. 10.

surface on which they stand, and unbending it with force, they are out of your reach before your finger can come near them. One of them, *S. fuscus*, besides the caudal fork, has a very singular organ, the use of which is to prevent it from falling from a perpendicular surface, on which they are often found at a great height from the ground. Between the ends of the fork there is an elevated cylinder or tube, from which the animal, when necessary, can protrude two long, filiform, flexible transparent threads covered with a slimy secretion. By these, when it has lost its hold, it adheres to the surface on which it is stationed[a]. Another insect related to the common sugar-louse, and called by Latreille *Machilis polypoda* (*Lepisma*, F.), in some places common under stones[b], has eight pair of springs, one on each ventral segment of the abdomen, by means of which it leaps to a wonderful distance, and with the greatest agility.

Climbing is another motion of insects that merits particular consideration: since, as this includes their power of moving against gravity—as we see flies and spiders do upon our ceilings, and up perpendicular surfaces even when of glass—it affords room for much interesting and curious inquiry. Climbing insects may be divided into four classes.—Those that climb by means of their claws;—those that climb by a soft cushion of dense hairs, that, more or less, lines the underside of the joints of their tarsi, the claw-joint excepted;—those that climb by the aid of suckers, which adhere (a vacuum being produced between them and the plane of position) by the pressure of the atmosphere;—and those that are enabled

[a] De Geer, vii. 38—. *t.* iii. *f.* 10. *rr.*

[b] This insect abounds at East Farleigh, near Maidstone.

to climb by means of some substance which they have the power of secreting.

The first order of climbers—those that climb by means of their *claws*—includes a large proportion of insects, especially in the *Coleoptera* order—the majority of those that have five joints in their tarsi being of this description. The predaceous tribes, particularly the numerous and prowling ground-beetles (*Carabidæ*), often thus ascend the plants and trees after their prey. Thus one of them, the beautiful but ferocious *Calosoma Sycophanta*, mounts the trunk and branches of the oak to commit fearful ravages amongst the hordes of caterpillars that inhabit it[a]. By these the less savage but equally destructive tree-chafers (*Melolonthæ*), and those enemies of vegetable beauty the rose-chafers (*Cetonia aurata*), are enabled to maintain their station on the trees and shrubs that they lay waste. And by these also the water-beetles (*Dytiscus*, *Hydrophilus*, &c.) climb the aquatic plants.—But it is unnecessary further to enlarge upon this head; I shall only observe, that in most of the insects here enumerated, the claws appear to be aided by stiff hairs or bristles.

Other climbers ascend by means of *cushions* (*pulvilli*) composed of hairs, as thickly set as in plush or velvet, with which the underside of the joints of their tarsi—the claw-joint, which is always naked, excepted—are covered. These cushions are particularly conspicuous in the beautiful tribe of plant-beetles (*Chrysomela*, F.). A common insect of this kind, before mentioned, called the bloody-nose beetle (*C. tenebricosa*), by the aid of these is enabled to adhere to the trailing plants, the various species of bed-

[a] Reaum. ii. 457.

straw (*Galium*), on which it feeds; and by these will support itself against gravity; for both this and *C. goettingensis* will walk upon the hand with their back downwards, and it then requires a rather strong pull to disengage them from their station.—The whole tribe of weevils (*Curculionidæ*) are also furnished with these cushions, but not always upon all their joints, some having them only at their apex; and the palm-weevil (*Calandra Palmarum*, F.) at the extremity solely of the last joint but one. —Those brilliant beetles the *Buprestes* have also these cushions, as have likewise the numerous tribes of capricorn-beetles (*Cerambycidæ*). The larvæ of these being timber-borers, the parent insect is probably thus enabled to adhere to this substance whilst it deposits its eggs. Indeed in some species of the former genus the cushions wear the appearance of suckers.—While the linear species of *Helops*, F. are without them, they clothe all the tarsi of *H. æneus*[a]. In two other genera of the same order, *Silpha* and *Cicindela*, the anterior tarsi of the males are furnished with them; in these therefore they may be regarded, like the suckers of the larger water-beetles (*Dytisci*), as given for sexual purposes. The three first joints of the anterior tarsi of many of the larger rove-beetles (*Staphylinus*, L.) are dilated so as to form, as in the last-mentioned insects, an orbicular patella, but covered by cushions. Since in them this is not peculiar to the males, it is probably given that they may be able to support their long bodies when climbing.

But the most remarkable class of climbers consists of

[a] The insect alluded to under this name, answers to Fabricius's description of *H. æneus*, but from Olivier's figure appears distinct from it.

those that are furnished with an apparatus by which they can form a *vacuum*, so as to adhere to the plane on which they are moving by atmospheric pressure. That flies can walk upon glass placed vertically, and in general against gravity, has long been a source of wonder and inquiry; and various have been the opinions of scientific men upon the subject. Some imagined that the suckers on the feet of these animals were spunges filled with a kind of gluten, by which they were enabled to adhere to such surfaces. This idea, though incorrect, was not so absurd as at first it may seem; since we have seen above in many instances, and very lately in that of the *Sminthurus fuscus*, that insects are often aided in their motions by a secretion of this kind. Hooke appears to have been one of the first who remarked that the suspension of these animals was produced by some mechanical contrivance in their feet. Observing that the claws alone could not effect this purpose, he justly concluded that it must be principally owing to the mechanism of the two palms, pattens, or soles as he calls the suckers; these he describes as beset underneath with small bristles or tenters, like the wire teeth of a card for working wool, which having a contrary direction to the claws, and both pulling different ways, if there be any irregularity or yielding in the surface of a body, enable the fly to suspend itself very firmly. That they walk upon glass, he ascribes to some ruggedness in the surface; and principally to a smoky tarnish which adheres to it, by means of which the fly gets footing upon it[a]. But these tenter-hooks in the suckers of flies, and this smoky tarnish upon glass, are

[a] *Microgr.* 170.

mere fancies, since they can walk as well upon the cleanest glass as upon the most tarnished. Reaumur also attributes this faculty of these animals to the hairs upon their suckers[a]. That learned and pious naturalist, Dr. Derham, seems to have been one of the first who gave the true solution of this enigma. "Flies," says he, "besides their sharp hooked nails, have also skinny palms to their feet, to enable them to stick on glass and other smooth bodies, by the *pressure of the atmosphere*[b]." He compares these palms to the curious suckers of male *Dytisci*, before alluded to, and illustrates their action by a common practice of boys, who carry stones by a wet piece of leather applied to their top. Another eminent and excellent naturalist, the late Mr. White, adopted this solution. He observes that in the decline of the year, when the mornings and evenings become chilly, many species of flies retire into houses and swarm in the windows: that at first they are very brisk and alert; but, as they grow more torpid, that they move with difficulty, and are scarcely able to lift their legs, which seem as if glued to the glass; and that by degrees many do actually stick till they die in the place. Then noticing Dr. Derham's opinion as just stated, he further remarks, that they easily overcome the atmospheric pressure when they are brisk and alert. But, he proceeds, in the decline of the year this resistance becomes too mighty for their diminished strength; and we see flies labouring along, and lugging their feet in windows as if they stuck fast to the glass[c].

Sir Joseph Banks, to whom every branch of Natural

[a] iv. 259. [b] *Physico-Theol.* Ed. 13. 363, note *b.*
[c] *Nat. Hist.* ii. 274.

History becomes daily more indebted, has lately excited an inquiry, the results of which have confirmed Derham's system concerning this motion of animals against gravity. When abroad, he had noticed that a lizard, on account of the sound that it emits before rain, named the Gecko[a] (*Lacerta Gecko*, L.), could walk against gravity up the walls of houses; and comparing this with the parallel motions of flies, he was desirous of having the subject more scientifically illustrated than it had been. This inquiry was put into the able hands of Sir Everard Home, so justly celebrated as a comparative anatomist, who was assisted in it by the incomparable pencil of Mr. Bauer: and it has been proved most satisfactorily, that it is by producing a vacuum between certain organs destined for that purpose and the plane of position, sufficient to cause atmospheric pressure upon their exterior surface, that the animals in question are enabled to walk up a

[a] *Amœn. Acad.* i. 549. The Gecko, probably, is not the only lizard that walks against gravity. St. Pierre mentions one not longer than a finger, that, in the Isle of France, climbs along the walls, and even up the glass after the flies and other insects, for which it watches with great patience. These lizards are sometimes so tame that they will feed out of the hand.—*Voyage*, &c. 73. Major Moor and Captain Green observed similar lizards in India, that ran up the walls and over the ceilings after the mosquitos. Hasselquist says that the Gecko is very frequent at Cairo, both in the houses and without them, and that it exhales a very deleterious poison from the lobuli between the toes. He saw two women and a girl at the point of death, merely from eating a cheese on which it had dropped its venom. One ran over the hand of a man, who endeavoured to catch it; and immediately little pustules, resembling those occasioned by the stinging-nettle, rose all over the parts the creature had touched.—*Voyage*, 220. M. Savigny, however, who examined this animal in Egypt, assures me that the account of Hasselquist's, as far as it relates to the venom of the Gecko, is not correct.

polished perpendicular, like the glass in our windows and the chunam walls in India, or with their backs downward on a ceiling, without being brought to the ground by the weight of their bodies.

The instruments by which a fly effects this purpose are two suckers connected with the last joint of the tarsus by a narrow infundibular neck, which has power of motion in all directions, immediately under the root of each claw. These suckers consist of a membrane capable of extension and contraction; they are concavo-convex with serrated edges, the concave surface being downy, and the convex granulated. When in action they are separated from each other, and the membrane expanded so as to increase the surface: by applying this closely to the plane of position, the air is sufficiently expelled to produce the pressure necessary to keep the animal from falling. When the suckers are disengaged, they are brought together again so as to be confined within the space between the two claws. This may be seen by looking at the movements of a fly in the inside of a glass tumbler with a common microscope[a]. Thus the fly you see does no more than the leach has been long known to do, when moving in a glass vessel. Furnished with a sucker at each extremity, by means of these organs it marches up and down at its pleasure, or as the state of the atmosphere inclines it.

Dipterous insects, which in general have these organs, and some three on each foot[b], are not exclusively gifted with them; for various others in different orders have them, and some in greater numbers. As I lately

[a] *Philos. Trans.* 1816. 325. *t.* xviii. *f.* 1-7. [b] Ibid. *f.* 8-11.

observed, the cushions of the Buprestes are something very like them, particularly those of *B. fascicularis*, L.—A Brazilian beetle in my cabinet, belonging to the family of the *Cleridæ*, but not arranging well under any of Latreille's genera, which I have named *Priocera variegata*, has curious involuted suckers on its feet.—The strepsipterous genera *Stylops*, K. and *Xenos*, R., are remarkable for the vesicles of membrane that cover the underside of their tarsi, which, though flaccid in old specimens, appear to be inflated in the living animal or those that are recent[a]. It is not improbable that these vesicles, which are large and hairy, may act in some degree as suckers, and assist it in climbing.

The insects of the *Orthoptera* order are, many of them, remarkable for two kinds of appendages connected with my present subject, being furnished both with suckers and cushions. The former are concavo-convex processes, varying in shape in different species—being sometimes orbicular, sometimes ovate or oblong, and often wedge-shaped—which terminate the tarsus between the claw, one on each foot. They are of a hard substance, and seem capable of free motion. In some instances[b], another minute cavity is discoverable at the base of the concave part, similar to that in *Cimbex lutea*[c]. The latter, the cushions, are usually convex appendages, of an oblong form, and often, though not always, divided in the middle by a very deep longitudinal furrow, attached to the underside of the tarsal joints. Sir E. Home is of opinion that the object of these cushions is to take

[a] Kirby in *Linn. Trans.* xi. 106. *t.* viii. *f.* 13. *a.*

[b] I observed this in the hind legs of a variety of *Gryllus migratorius*.

[c] *Philos. Trans.* 1816. *t.* xix. *f.* 5.

off the jar, when the body of the animal is suddenly brought from a state of motion to a state of rest[a]. This may very likely be one of their uses, but there are several circumstances which militate against its being the only one. By their elasticity they probably assist the insects that have them in their leaps; and when they climb they may in some degree act as suckers, and prevent them from falling. But their use will be best ascertained by a review of the principal genera of the order. Of these the cock-roaches (*Blatta*), the spectres (*Phasma*), and the praying-insects (*Mantis*), are distinguished by tarsi of five joints[b]. The grasshoppers with setaceous antennæ (*Locusta*, F.) have four tarsal joints. Those with filiform antennæ (*Gryllus*, F. and *Acrydium*, F.), those with ensiform (*Truxalis*, F.), and the crickets (*Acheta*, F.), have only three. In *Blatta*, the variations with respect to the suckers and cushions (for many species are furnished with both) are remarkable. The former in some (*Blatta gigantea*, L.) are altogether wanting; in others (*B. Petiveriana*, L.) they are mere rudiments; and in others (*B. Maderæ*) they are more conspicuous, and resemble those of the *Gryllidæ*. The cushions also in some are nearly obsolete, and occupy the mere extremity of the four first tarsal joints (*B. orientalis*, *americana*, *capensis*, &c.). In *B. Petiveriana* there is none upon the first joint; but

[a] *Philos. Trans.* 1816. p. 325.

[b] In a specimen in my cabinet of *Blatta gigantea*, the posterior and anterior tarsi of one side have only four joints, while the intermediate one has five. On the other side the hind leg is broken off, but the anterior and intermediate tarsi have both five joints. In another specimen one posterior tarsus has four and the other five joints.

upon the extremity of the four last, not excepting the claw-joint, there is a minute orbicular concave one, resembling a sucker. In others (*B. gigantea*, &c.) they extend the length of the four first joints, and are very conspicuous. In some (*B. Mouffeti*, K.[a],) which have no claw-sucker, there appears to be a cavity in the extremity of the claw-joint, which may serve the purpose of one. These cushions are usually of a pale colour; but in one specimen of a hairy female which I have, from Brazil, they are black. The spectre genus (*Phasma*) exhibits no particular varieties in this respect. The tarsal joints of the legs have cushions at their apex, which appear to be bifid. They have a large orbicular sucker between the claws. In *Mantis* the fore feet have neither of the parts in question, and the others have no suckers. They have cushions on the four first tarsal joints of the two last pair of legs, which, though smaller, are shaped much like those in *Phasma*. In *Locusta* the feet have no suckers between the claws, but they are distinguished by two oval, soft, concave, and moveable processes attached to the base of the first joint of the tarsus, which probably act as suckers[b]. In this genus there are two cushions on the first joint of the tarsi, and one on each of the two following ones[c].—The species of

[a] This insect, which is remarkable for having the margin of its thorax reflexed, was long since well figured in Mouffet's work (130. *fig. infima.*). It has not, however, been described by any other author I have met with. It is common in Brazil. Some specimens are pallid, while others are of a dark brown.

[b] De Geer, iii. 421. *t.* xxi. *f.* 13. *h.* This author has also noticed the cushions in this genus and *Gryllus*, and the claw-sucker in the latter, which he thinks are analogous to those of the fly. *Ibid.* 462. *t.* xxii. *f.* 7-8.

[c] *Philos. Trans.* 1816. *t.* xxi. *f.* 8-13.

the Fabrician genus *Gryllus* come next. This genus is now called *Acrydium* by Latreille after Geoffroy; but, since it includes the true *locust*, it ought to have retained the name *Locusta* given by Linné to the tribe to which it belongs. All these insects have the terminal sucker between the claws, three cushions on the first joint of the tarsus, and one on the second[a]; and the same conformation also distinguishes the feet of *Truxalis*, F. In the species of *Acrydium*, F. (*Tetrix*, Latr.), the cushions, I believe—for in the dead insect they are the reverse of conspicuous—are arranged nearly as in the two preceding genera, but these insects are without the claw-sucker. And lastly, *Acheta*, F., has neither suckers nor cushions. From this statement it seems to follow—since *Blatta*, *Phasma*, and *Mantis*, that do not leap, are provided with cushions; and *Acheta*, F., a heavy tribe of insects that does, are without them—that their object cannot be exclusively to break the fall of the insects that have them. And for the same reason we may conclude, that they must have some further use than augmenting their elasticity when they jump. When we consider that *Blattæ*—many of which have no suckers, or very small ones—are climbing insects (I have seen *B. germanica* run up and down the walls of an apartment with great agility), and that the long and gigantic apterous spectres &c. (*Phasma*) require considerable means to enable them to climb the trees in which they feed, and to maintain their station upon them, we may conclude that these cushions, by acting in some degree as suckers, may promote these ends.

[a] *Philos. Trans.* 1816. *t.* xxi. *f.* 1-9.

Amongst the *Hemiptera*, *Chermes* and many of the *Cicadiadæ*[a] are furnished with the claw-suckers; but the noisy *Tettigoniæ*, as well as the tribes of *Cimicidæ*, at least as far as my examination of them has gone, have them not. De Geer has observed, speaking of a small fly of this order (*Thrips Physapus*, L.), that the extremity of its feet is furnished with a transparent membranaceous flexible process, like a bladder. He further says that, when the animal fixes and presses this vesicle on the surface on which it walks, its diameter is increased, and it sometimes appears concave, the concavity being in proportion to the pressure; which made him suspect that it acted like a cupping-glass, and so produced the adhesion[b]. This circumstance affords another proof that the cushions in the *Orthoptera* may act the same part; they appear to be vesicular; and in numbers of specimens, after death, I have observed that they become concave, particularly in *Locusta viridissima*.

In *Cimbex*, and others amongst the saw-fly tribes (*Tenthredinidæ*), the claw-sucker is distinguished by this remarkable peculiarity, that its upper surface is concave[c], so that before it is used it must be bent inwards. Besides these, at the extremity of each tarsal joint these animals are furnished with a spoon-shaped sucker, which seems analogous to the cushions in the *Gryllidæ*: and, what is more remarkable, the two spurs (*calcaria*) at the apex of the shanks have likewise each a minute one[d].—Various other insects of this order have the claw-suckers. Amongst others the common wasp (*Vespa vulgaris*) is by these enabled to walk up and down our glass windows.

[a] De Geer, iii. 132. 173. [b] Ibid. 7.

[c] *Philos. Trans.* 1816. *t.* xix. *f.* 3, 4. [d] Ibid. *t.* xix. *f.* 1-9.

We learn from De Geer that several mites (*Acaridæ*), to finish with the *Aptera*, have something of this kind. Among these is the cheese-mite (*Acarus Siro*, F.): its four fore feet being terminated by a vesicle with a long neck, to which it can give every kind of inflexion. When it sets its foot down, it enlarges and inflates it; and when it lifts it up, it contracts it so that the vesicle almost entirely disappears. This vesicle is between two claws[a].—The itch acarus (*A. Scabiei*, L.) is similarly circumstanced. —*Ixodes Ricinus* and *Reduvius* have also these vesicles—which are armed with two claws—on all their feet[b].

I am next to consider those climbers that ascend and descend, and probably maintain themselves in their station, by the assistance of a *secretion* which they have the power of producing. You will immediately perceive that I am speaking of the numerous tribes of spiders (*Araneidæ*), which, most of them, are endowed with this faculty. Every body knows that these insects ascend and descend by means of a thread that issues from them; but perhaps every one has not remarked—when they wish to avoid a hand held out to catch them, or any other obstacle—that they can sway this thread from the perpendicular. When they move up or down, their legs are extended, sometimes gathering in and sometimes guiding their thread[c]; but when their motion is suspended, they are bent inwards. These animals, although they have no suckers or other apparatus—except the hairs of their legs and the three claws of their biarticulate tarsi, to enable them to do it—can also walk against

[a] De Geer, vii. 91. *t.* v. *f.* 6, 7.
[b] Ibid. 96— *t.* v. *f.* 13, 14, 17, 19. *t.* vi *f.* 2, 5.
[c] Vol. I. 4th Ed. 407.

gravity, both in a perpendicular and a prone position. Dr. Hulse, in Ray's *Letters*, seems to have furnished a clue that will very well explain this. I give it you in his own homely phrase. "They," spiders, "will often fasten their threads in several places to the things they creep up; the manner is by beating their bums or tails against them as they creep along[a]." Fixing their anus by means of a web, the anterior part of their body, when they are resting, we can readily conceive, would be supported by the claws and hairs of their legs; and their motion may be accomplished by alternately fixing one and then the other. But you will remember I give you this merely as conjecture, having never verified it by observation.

It may not be amiss to mention here another apterous insect that reposes on perpendicular or prone surfaces, without either suckers or any viscous secretion by which it can adhere to them. I mean the long-legged or shepherd spiders (*Phalangium*, L.). The tarsi of these insects are setaceous and nearly as fine as a hair, consisting sometimes of more than forty joints, those toward the extremity being very minute, and scarcely discernible, and terminating in a single claw. These tarsi, which resemble antennæ rather than feet, are capable of every kind of inflexion, sometimes even of a spiral one. These circumstances enable them to apply their feet to the inequalities of the surface on which they repose, so that every joint may in some measure become a point of support. Their eight legs also, which diverge from their body like the spokes from the nave of a wheel, give them

[a] 65.

equal hold of eight almost equidistant spaces, which, doubtless, is a great stay to them.

The next species of locomotion exhibited by perfect insects is *flying*. I am not certain whether under this head I ought to introduce the sailing of spiders in the air; but as there is no other under which it can be more properly arranged, I shall treat of it here. I shall therefore divide flying insects into those that fly without wings, and those that fly with them.

I dare say you are anxious to be told how any animals can fly *without wings*, and wish me to begin with them. As an observer of nature, you have often, without doubt, been astonished by that sight occasionally noticed in fine days in the autumn, of webs—commonly called gossamer webs—covering the earth and floating in the air; and have frequently asked yourself—What are these gossamer webs? Your question has from old times much excited the attention of learned naturalists. It was an old and strange notion that these webs were composed of dew burned by the sun.

> "..... The fine nets which oft we woven see
> Of scorched dew,"

says Spenser. Another, fellow to it, and equally absurd, was that adopted by a learned man and good natural philosopher, and one of the first fellows of the Royal Society, Robert Hooke, the author of *Micrographia*. "Much resembling a cobweb," says he, "or a confused lock of these cylinders, is a certain white substance which, after a fogg, may be observed to fly up and down the air: catching several of these, and examining them with my microscope, I found them to be much of the

same form, looking most like to a flake of worsted prepared to be spun; though by what means they should be generated or produced is not easily imagined: they were of the same weight, or very little heavier than the air; *and 'tis not unlikely, but that those great white clouds, that appear all the summer time, may be of the same substance*[a]." So liable are even the wisest men to error when, leaving fact and experiment, they follow the guidance of fancy. Some French naturalists have supposed that these *fils de la Vierge*, as they are called in France, are composed of the cottony matter in which the eggs of the Coccus of the vine (*C. Vitis*, L.) are enveloped[b]. In a country abounding in vineyards this supposition would not be absurd; but in one like Britain, in which the vine is confined to the fruit-garden, and the Coccus seldom seen out of the conservatory, it will not at all account for the phænomenon. What will you say, if I tell you that these webs (at least many of them) are air-balloons—and that the aëronauts are not

> "Lovers who may bestride the gossamer
> That idles in the wanton summer air,
> And yet not fall"—

but *spiders*, who long before Montgolfier, nay, ever since the creation, have been in the habit of sailing through the fields of ether in these air-light chariots! This

[a] *Microgr.* 202. It has been objected to an excellent primitive writer (*Clemens Romanus*), that he believed the absurd fable of the phœnix. But surely this may be allowed for in him, who was no naturalist, when a scientific natural philosopher could believe that the clouds are made of spiders web!

[b] Latreille, *Hist. Nat.* xii. 388.

seems to have been suspected long ago by Henry Moore, who says,

> "As light and thin as cobwebs that do fly
> In the blew air, caus'd by the autumnal sun,
> That boils the dew that on the earth doth lie,
> May seem this whitish rag then is the scum;
> *Unless that wiser men make't the field-spider's loom*[a]."

Where he also alludes to the old opinion of scorched dew. But the first naturalists who made this discovery appear to have been Dr. Hulse and Dr. Martin Lister—the former first observing that spiders shoot their webs into the air; and the latter, besides this, that they were carried upon them in that element[b]. This last gentleman, in fine serene weather in September, had noticed these webs falling from the heavens, and in them discovered more than once a spider, which he named the *bird*. On another occasion, whilst he was watching the proceedings of a common spider, the animal suddenly turning upon its back and elevating its anus, darted forth a long thread, and vaulting from the place on which it stood, was carried upwards to a considerable height. Numerous observations afterwards confirmed this extraordinary fact; and he further discovered, that while they fly in this manner, they pull in their long thread with their fore feet, so as to form it into a ball—or, as we may call it, air-balloon—of flake. The height to which spiders will thus ascend he affirms is prodigious. One day in the autumn, when the air was full of webs, he mounted to the top of the highest steeple of York minster, from whence he could discern the floating webs still very

[a] Quoted in the *Athenæum*, v. 126. [b] Ray's *Letters*, 69. 36—

high above him. Some spiders that fell and were entangled upon the pinnacles he took. They were of a kind that never enter houses, and therefore could not be supposed to have taken their flight from the steeple[a]. It appears from his observations, that this faculty is not confined to one species of spider, but is common to several, though only in their young or half-grown state[b]; whence we may infer, that when full-grown their bodies are too heavy to be thus conveyed. One spider he noticed that at one time contented itself with ejaculating a single thread, while at others it darted out several, like so many shining rays at the tail of a comet. Of these, in Cambridgeshire in October, he once saw an incredible number sailing in the air[c]. Speaking of his *Ar. subfuscus minutissimis oculis*, &c. he says, "Certainly this is an excellent rope-dancer, and is wonderfully delighted with darting its threads: nor is it only carried in the air, like the preceding ones; but it effects itself its ascent and sailing: for, by means of its legs closely applied to each other, it as it were balances itself, and promotes and directs its course no otherwise than as if nature had furnished it with wings or oars[d]." A later but equally gifted observer of nature, Mr. White, confirms Dr. Lister's account. "Every day in fine weather in autumn," says he, "do I see these spiders shooting out their webs, and mounting aloft: they will go off from the finger, if

[a] Ray's *Letters*, 37. 87. Lister *De Aran.* 80. Lister illustrates the force with which these creatures shoot their thread, by a homely though very forcible simile: "Resupinata (says he) anum in ventum dedit, filumque ejaculata est quo plane modo robustissimus juvenis e distentissima vesicâ urinam."

[b] *De Araneis*, 8. 27. 64. 75—. 79—. [c] Ibid. 79—. [d] Ibid. 85.

you will take them into your hand. Last summer one alighted on my book as I was reading in the parlour; and running to the top of the page and shooting out a web, took its departure from thence. But what I most wondered at was, that it went off with considerable velocity in a place where no air was stirring; and I am sure that I did not assist it with my breath. So that these little crawlers seem to have while mounting some locomotive power without the use of wings, and move faster than the air in the air itself[a]." A writer in the last number of Thomson's *Annals of Philosophy*[b], under the signature of Carolan, has given some curious observations on the mode in which some geometric spiders shoot and direct their threads, and fly upon them; by which it appears, that as they dart them out they guide them as if by magic, emitting at the same time a stream of air, as he supposes, or possibly some subtile electric fluid. One which was running upon his hand, dropped by its thread about six inches from the point of his finger, when it immediately emitted a pretty long line at a right angle with that by which it was suspended. This thread, though at first horizontal, quickly rose upwards, carrying the spider along with it. When it had ascended as far above his finger as it had dropped before below it, it let out the thread by which it had been attached to it, and continued flying smoothly upwards till it nearly reached the roof of the room, when it veered on one side and alighted on the wall. In flying, its motion was smoother and quicker than when a spider runs along its thread. He observes, that as the line lengthens behind them, the tendency of spiders to rise increases.—I

[a] *Nat. Hist.* i. 327. [b] No. lii. 306—.

have myself more than once observed these creatures take their flight, and find the following memorandum with respect to their mode of proceeding. "The spider first extends its thighs, shanks, and feet, into a right line, and then elevating its abdomen till it becomes vertical, shoots its thread into the air, and flies off from its station." It is not often, however, that an observer can be gratified with this interesting sight, since these animals are soon alarmed. I have frequently noticed them—for at the times when these webs are floating in the air they are very numerous—on the vertical angle of a post, or pale, or one of the uprights of a gate, with the end of their abdomen pointing upwards, as if to shoot their thread previously to flying off; when, upon my approaching to take a nearer view, they have lowered it again, and persisted in disappointing my wish to see them mount aloft. The rapidity with which the spider vanishes from the sight upon this occasion and darts into the air, is a problem of no easy solution. Can the length of web that they dart forth counterpoise the weight of their bodies? Or have they any organ analogous to the natatory vesicles of fishes[a], which contributes at their will to render them buoyant in the air? Or do they rapidly ascend their threads in their usual way, and gather them up, till having collected them into a mass of sufficient magnitude, they give themselves to the air, and are carried here and there in these chariots? I must here give you Mr. White's very curious account of a shower of these webs that he witnessed. On the 21st of September 1741, intent upon field diversions, he rose before day-break; but on going out, he found the whole

[a] Cuvier, *Anat. Comp.* i. 504.

face of the country covered with a thick coat of cobweb drenched with dew, as if two or three setting-nets had been drawn one over the other. When his dogs attempted to hunt, their eyes were so blinded and hoodwinked that they were obliged to lie down and scrape themselves. This appearance was followed by a most lovely day. About nine A. M. a shower of these webs (formed not of single floating threads, but of perfect flakes, some near an inch broad, and five or six long,) was observed falling from very elevated regions, which continued without interruption during the whole of the day;—and they fell with a velocity which showed that they were considerably heavier than the atmosphere. When the most elevated station in the country where this was observed was ascended, the webs were still to be seen descending from above, and twinkling like stars in the sun, so as to draw the attention of the most incurious. The flakes of the web on this occasion hung so thick upon the hedges and trees, that baskets-full might have been collected. No one doubts, he observes, but that these webs are the production of small spiders, which swarm in the fields in fine weather in autumn, and have a power of shooting out webs from their tails, so as to render themselves buoyant and lighter than the air[a]. In Germany these flights of gossamer appear so constantly in autumn, that they are there metaphorically called "*Der fliegender Sommer*" (the flying or departing summer); and authors speak of the web as often hanging in flakes like wool on every hedge and bush throughout extensive districts.

Here we may inquire—Why is the ground in these

[a] *Nat. Hist.* i. 325—.

serene days covered so thickly by these webs, and what becomes of them? What occasions the spiders to mount into the air, and do the same species form both the terrestrial and aërial gossamer?—And what causes the webs at last to fall to the earth? I fear I cannot to all these queries return a fully satisfactory answer; but I will do the best I can. At first one would conclude from analogy, that the object of the gossamer which early in the morning is spread over stubbles and fallows—and sometimes so thickly as to make them appear as if covered with a carpet, or rather overflown by a sea, of gauze, presenting, when studded with dew-drops, as I have often witnessed, a most enchanting spectacle—is to entrap the flies and other insects as they rise into the air from their nocturnal station of repose, to take their diurnal flights. But Dr. Strack's observations render this very doubtful; for he kept many of the spiders that produce these webs in a large glass upon turf, where they spun as when at liberty, and he could never observe them attempt to catch or eat—even when entangled in their webs—the flies and gnats with which he supplied them; though they greedily sucked water when sprinkled upon the turf, and remained lively for two months without other food[a]. As the single threads shot by other spiders are usually their bridges, this perhaps may be the object of the webs in question: and thus the animals may be conveyed from furrow to furrow or straw to straw less circuitously, and with less labour, than if they had travelled over the ground. As these creatures seem so thirsty, may we not conjecture that the drops of dew,

[a] *Neue Schriften der Naturforschenden Gessellschaft zu Halle* 1810. v. *Heft.*

with which they are always as it were strung, are a secondary object with them? So prodigious are their numbers, that sometimes every stalk of straw in the stubbles, and every clod and stone in the fallows, swarms with them. Dr. Strack assures us that twenty or thirty often sit upon a single straw, and that he collected about 2000 in half an hour, and could have easily doubled the number had he wished it: he remarks, that the cause of their escaping the notice of other observers, is their falling to the ground upon the least alarm.

As to what becomes of this immense carpeting of web there are different opinions. Mr. White conjectures that these threads, when first shot, might be entangled in the rising dew, and so drawn up, spiders and all, by a brisk evaporation, into the region where the clouds are formed[a]. But this seems almost as inadmissible as that of Hooke, before related. An ingenious and observant friend, thinking the numbers of the flying spiders not sufficient to produce the whole of the phenomenon in question, is of opinion that an equinoctial gale, sweeping along the fallows and stubbles coated with the gossamer, must bring many single threads into contact, which, adhering together, may gradually collect into flakes; and that being at length detached by the violence of the wind, they are carried along with it: and as it is known that such winds often convey even sand and earth to great heights, he deems it highly probable that so light a substance may be transported to so great an elevation, as not to fall to the earth for some days after, when the weather has become serene, or to descend upon

[a] *Nat. Hist.* i. 326.

ships at sea, as has sometimes happened. This, which is in part adopted from the German authors, is certainly a much more reasonable supposition than the other; but some facts seem to militate against it: for, in the first place, though gossamer often occurs upon the ground when there is none in the air, yet the reverse of this has never been observed; for gossamer in the air, as in the instance recorded by Mr. White, is always preceded by gossamer on the ground. Now, since the weather is constantly calm and serene when these showers appear, it cannot be the wind that carries the web from the ground into the air. Again, it is stated that these showers take place after *several* calm days [a]: now, if the web was raised by the wind into the air, it would begin to fall as soon as the wind ceased. Whence I am inclined to think that the cause assigned by Dr. Lister is the real source of the whole phenomenon. Though ordinary observers have overlooked them, he noticed these spiders in the air in such prodigious numbers, that he deemed them sufficient to produce the effect. I shall not, however, decide positively; but, having stated the different opinions, leave you to your own judgement.

The next query is, What occasions the spiders to mount their chariots and seek the clouds? Is it in pursuit of their food? Insects, in the fine warm days in which this phenomenon occurs, probably take higher flights than usual, and seek the upper regions of the atmosphere; and that the spiders catch them there, appears by the exuviæ of gnats and flies, which are often found in the falling webs [b]. Yet one would suppose that

[a] Ray's *Letters*, 36. [b] Ibid. 42. Lister *De Araneis*, 8.

insects would fly high at all times in the summer in serene warm weather. Perhaps the flight of some particular species constituting a favourite food of our little charioteers—the gnats, for instance, which we have seen sometimes rise in clouds into the air[a]—may at these times take place; or the species of spiders that are most given to these excursions, may not abound in their young state—when only they can fly—at other seasons of the year.

Whether the same species that cover the earth with their webs produce those that fill the air, is to be our next inquiry. Did the appearance of the one always succeed that of the other, this might be reasonably concluded:—but the former, as I lately observed to you, often occurs without being followed by the latter. Yet, since it should seem that the aërial gossamer, though it does not always follow it, is always preceded by the terrestrial, this warrants a conjecture that they may be synonymous. Two German authors, Bechstein[b] and Strack[c], have described the spider that produces gossamer in Germany under the name of *Aranea obtextrix*[b]. But it is not clear, unless they have described it at different ages, when spiders often greatly change their appearance, that they mean the same species. The former describes his as of the size of a small pin's head, with its eight eyes disposed in a circle, having a black-brown body and light-yellow legs: while Dr. Strack represents his *A. obtextrix* as more than two lines in length; eyes four in a square, and two on each side touching each

[a] Vol. I. 4th Ed. 115.

[b] Lichtenberg und Voight *Magazin*, 1789. vi. 53—.

[c] *Neve Schriften der Naturforsch.* &c. 1810. v. Heft. 41-56.

other; thorax deep brown with paler streaks; abdomen below dull white, above dark copper brown, with a dentated white spot running longitudinally down the middle. The first of these, if distinct, as I suspect they are, agrees very well with the young of one which Lister observed as remarkable for taking aërial flights[a]; and which I have most usually seen so engaged. The other may possibly be that before noticed, which he found in such infinite numbers in Cambridgeshire[b]. If this conjecture be correct, it will prove that the same species first produce the gossamer that covers the ground, and then, shooting other threads, mount upon them into the air.

My last query was, What causes these webs ultimately to fall to the earth? Mr. White's observation will I think furnish the best answer. "If the spiders have the power of coiling up their webs in the air, as Dr. Lister affirms, then when they become heavier than the air they will fall[c]." The more expanded the web, the lighter and more buoyant, and the more condensed, the heavier it must be.

I trust you will allow from this mass of evidence, that the English *Arachnologists*—may I coin this term?—were correct in their account of this singular phenomenon; and think, with me, that Swammerdam (who however admits that spiders sail on their webs), and after him De Geer, were rather hasty when they stigmatized the discovery that these animals shoot their webs into the air, and so take flight, as a strange and unfounded opinion[d]. The fact, though so well authenticated, is indeed strange

[a] *De Araneis*, 66. [b] Ibid. 79. [c] *Nat. Hist.* i. 326.
[d] Swamm. *Bibl. Nat.* Ed. Hill, i. 24. De Geer, vii. 190.

and wonderful, and affords another proof of the extraordinary powers, unparalleled in the higher orders of animals, with which the Creator has gifted the insect world. Were indeed man and the larger animals, with their present propensities, similarly endowed, the whole creation would soon go to ruin. But these almost miraculous powers in the hands of these little beings only tend to keep it in order and beauty. Adorable is that Wisdom, Power, and Goodness, that has distinguished these next to nothings by such peculiar endowments for our preservation as if given to the strong and mighty would work our destruction.

After the foregoing marvellous detail of the aërial excursions of our insect air-balloonists, I fear you will think the motions of those which fly by means of *wings* less interesting. You will find, however, that they are not altogether barren of amusement. Though the wings are the principal instruments of the flight of insects, yet there are others subsidiary to them, which I shall here enumerate, considering them more at large under the orders to which they severally belong. These are wing-cases (*Elytra*, *Tegmina*, and *Hemelytra*); winglets (*Alulæ*); poisers (*Halteres*); tailets (*Caudulæ*); hooklets (*Hamuli*); base-covers (*Tegulæ*), &c. Besides, their *tails*, *legs*, and even *antennæ*, assist them, in some instances, in this motion.

As *wings* are common to almost the whole class, I shall consider their structure here. Every wing consists of two membranes, more or less transparent, applied to each other: the upper membrane being very strongly attached to the nervures (*Neuræ*), and the lower adhering more loosely, so as to be separable from them. The

nervures[a] are a kind of hollow tube,—above elastic, horny, and convex; and flat and nearly membranaceous below,—which take their origin in the trunk, and keep diminishing gradually, the marginal ones excepted, to their termination. The vessels contained in the nervures consist of a spiral thread, whence they appear to be air-vessels communicating with the tracheæ in the trunk. —The expansion of the wing at the will of the insect, is a problem that can only be solved by supposing that a subtile fluid is introduced into these vessels, which seem perfectly analogous to those in the wings of birds; and that thus an impulse is communicated to every part of the organ, sufficient to keep it in proper tension. We see by this, that a wing is supported in its flight like a sail by its cordage[b]. It is remarkable that those insects which keep the longest on the wing, the dragon-flies (*Libellulidæ*) for instance, have their wings most covered with nervures. The wings of insects in flying, like those of other flying animals, you are to observe, move vertically, or up and down.

In considering the flight of insects, I shall treat of that of each order separately, beginning with the *Coleoptera* or beetles. Their subsidiary instruments of flight are their wing-cases (*Elytra*), and in one instance, winglets (*Alulæ*). The former[c]—which in some are of a hard horny substance, and in others are softer and more like leather, though they are kept immoveable in flight, are probably, by their resistance to the air, not without their use on this

[a] French naturalists use this term (*nervure*) for the veins of wings, leaves, &c., restricting *nerve* (*nerf*) to the ramifications from the brain and spinal marrow. We have adopted the term, which we express in Latin by *neura*, from the Greek νευρα.

[b] Jurine *Hymenopt.* 19.

[c] PLATE X. FIG. 1.

occasion. The winglets are small concavo-convex scales, of a stiff membranaceous substance, generally fringed at their extremity[a]. I know at present of only one coleopterous insect that has them (*Dytiscus marginalis*, L.). They are placed under the elytra at their base. Their use is unknown; but it may probably be connected with their flight. The wings of beetles[b] are usually very ample, often of a substance between parchment and membrane. The nervures that traverse and extend them, though not numerous, are stronger and larger than those in the wings of insects of the other orders, and are so dispersed as to give perfect tension to the organ. When at rest—except in *Molorchus*, *Artractocerus*, *Necydalis*, and some other genera—they are folded transversely under the elytra, generally near the middle, with a lateral longitudinal fold, but occasionally near the extremity[c]. When they prepare for flight, their antennæ being set out, the elytra are opened so as to form an angle with the body and admit the free play of the wings, and they then fly off, striking the air by the vertical motion of these organs, the elytra all the while remaining immoveable. During their flight the bodies of insects of this order, as far as I have observed them, are always in a position nearly vertical, which gives to the larger sorts, the stag-beetle for instance, a very singular appearance. Olivier, probably having some of the larger and heavier beetles in his eye, affirms that the wings of insects of this order are not usually proportioned to the weight of their

[a] Plate XXIII. Fig. 6. *a*.

[b] Plate X. Fig. 4.

[c] In Plate XXIII. Fig. 5. the wings of *Dytiscus marginalis* are represented as they appear when folded.

bodies, and that the muscular apparatus that moves them is deficient in force. In consequence of which, he observes, they take flight with difficulty, and fly very badly. The strokes of their wings being frequent, and their flight short, uncertain, heavy, and laborious, they can use their wings only in very calm weather, the least wind beating them down. Yet he allows that others, whose body is lighter, rise into the air and fly with a little more ease; especially when the weather is warm and dry, their flights however being short, though frequent. He asserts also, that no coleopterous insect can fly against the wind[a]. These observations may hold perhaps with respect to many species; but they will by no means apply generally. The cockchafer (*Melolontha vulgaris*), if thrown into the air in the evening, its time of flight, will take wing before it falls to the ground. The common dung-chafer (*Geotrupes stercorarius*)—wheeling from side to side like the humble-bee—flies with great rapidity and force, and, with all its dung-devouring confederates, directs its flight with the utmost certainty, and probably often against the wind, to its food. The root-devourers or tree-chafers (*Melolontha*, *Hoplia*, &c.) support themselves, like swarming bees, in the air and over the trees, flying round in all directions. The *Staphylinidæ* and *Donaciæ*, in warm weather, fly off from their station with the utmost ease; —their wings are unfolded, and they are in the air in an instant, especially the latter, as I have often found when I have attempted to take them. None are more remarkable for this than the *Cicindelæ*, which, however, taking very short flights, are as easily marked down as a partridge,

[a] *Entomol.* i. 1.

and affords as much amusement to the entomologist, as the latter to the sportsman.—It is to be observed that many insects in this order have no wings, and the female glow-worms neither wings nor elytra.

Many persons are not aware that the insects of the next order, the *Dermaptera*, can fly: but earwigs (*Forficula*), their size considered, are furnished with very ample and curious wings, the principal nervures of which are so many radii, diverging from a common point near the anterior margin. Between these are others which, proceeding from the opposite margin, terminate in the middle of the wing[a]. These organs, when at rest, are more than once folded both transversely and longitudinally.

Wings equally ample, forming the quadrant of a circle, and with five or six nervures diverging from their base, distinguish the *strepsipterous* tribe. When unemployed these are folded longitudinally[b].

Probably in the next order (*Orthoptera*), the *Tegmina*, or wing-covers—since they are usually of a much thinner substance than elytra—assist them in flying. They are however quite covered by irregular reticulations, produced by various nervures sent forth by the longitudinal ones, and running in all directions. When at rest, the inner part of one laps over that of the other[c]: but in different genera there is a singular variation in this circumstance. Thus in *Blatta*, *Phasma*, and male *Locustæ*,

[a] PLATE X. FIG. 5. [b] PLATE II. FIG. 1. It has been ascertained that the spurious elytra of these insects are serviceable in their flight. As M. Latreille now allows this, he ought to have restored its original name, which he had altered, to this order.

[c] PLATE X. FIG. 2.

and generally speaking, but not invariably, in *Gryllus*, F. and *Truxalis*,—the left elytrum laps over the right: but in *Mantis*, F.; *Mantispa*, Latr.; some female *Locustæ*; *Acheta*; and *Gryllotalpa*, Latr.; the right is laid over the left. The wings in this order, though always ample and larger than the tegmina, do not invariably form a quadrant of a circle, falling often short of it. They are extended by means of nervures, which, like so many rays, diverge from the base of the wing, and are intersected alternately by transverse ones, which thus form quadrangular areas, arranged like bricks in a wall. When at rest, they are longitudinally folded. The flight of these insects, as far as it has been observed, much resembles, it is said, that of certain birds. Ray tells us that both sexes of the house-cricket (*Acheta domestica*, F.) fly with an undulating motion, like a woodpecker, alternately ascending with expanded wings, and descending with folded ones [a]. The field- and mole-crickets (*Acheta campestris* and *Gryllotalpa*, F.), as we learn from Mr. White [b],—and, since the structure of their wings is similar, probably the other *Orthoptera*,—fly in the same way.

Hemipterous insects, with respect to their *Hemelytra*, may be divided into two classes. Those in which they are all of the same substance—varying from membrane to a leathery or horny crust [c]—and those in which the base and the apex are of different substances; the first being generally corneous, and the latter membranaceous [d]. The former division includes the *Cicadiadæ*; *Aphis*; *Chermes*; *Thrips*; and *Coccus*;—and the latter the

[a] *Hist. Ins.* 63. [b] *Nat. Hist.* ii. 82.
[c] Plate II. Fig. 4. [d] Plate X. Fig. 3. II. Fig. 5.

Cimicidæ, comprehending besides the Linnean genus *Cimex, Notonecta*; *Sigara*; *Nepa*; *Ranatra*; and *Naucoris* of Fabricius. The posterior tibiæ of some of this last division (*Lygæus phyllopus, foliaceus*, &c., F.) are furnished on each side with a foliaceous process—which may act the part of out-riggers, and assist them in their flight[a]. I can give you no particular information with respect to the aërial movements of the insects of this order: the British species that belong to it are generally so minute that it is not easy to trace them with the naked eye; and unless some kind optician, which is much to be wished, would invent a telescope by which the proceedings of insects could be examined at a distance, there is no other way of studying them.

The four wings of the next order, the *Trichoptera* or case-worm flies, both in their shape and nervures resemble those of many moths[b]; only instead of scales they are usually covered with hairs, and the under wings, which are larger than the upper, fold longitudinally. Some of these flies, I have observed, move in a direct line, with their legs set out, which makes them look as if they were walking in the air. In flying they often apply their antennæ to each other, stretching them out straight, and thus probably are assisted in their motion.

The *Lepidoptera* vary so infinitely in the shape, comparative magnitude, and appendages of their wings, that I should detain you too long did I enlarge upon so multifarious a subject. I shall therefore only observe, that one species is described, both by Lyonet and De Geer[c] (*Phalæna hexaptera*, F.?), as having six wings;

[a] Plate XV. Fig 2. [b] Plate III. Fig. 4.

[c] Lesser, *L.* i. 109, note *. De Geer, ii. 460—. *t.* ix. *f.* 9.

for besides the four ordinary ones, it has a winglet (*Alula*) attached to the base of the lower one, and placed, when the wings are folded, between it and the upper. These organs in this order you know are covered with scales of various shape[a]. Their nervures are diverging rays, which issue either from a basal area or from the base itself, and terminate in the exterior margin[b]. The wings of many male butterflies, hawk-moths, and moths, are distinguished by a remarkable apparatus, noticed by De Geer, and since by many other naturalists[c], for keeping them steady and underanged in their flight. The upper wings, on their underside near their base, have a minute process, bent into a hook (*Hamus*), and covered with hairs and scales. In this hook one or more bristles (*Tendo*), attached to the base of the under-wing, have their play. When the fly unfolds its wings, the hook does not quit its hold of the bristle, which moves to and fro in it as they expand or close. The females, which seldom fly far, often have the bristles but never the hook. The hairy tails of some insects, *Sesia*, F., belonging to the hawk-moth tribe, are expanded when they fly, so as to form a kind of rudder, which enables them to steer their course with more certainty.

The insects of this, and of every other order, except the *Coleoptera*, fly with their bodies in a horizontal position, or nearly so. As their wings are usually so ample, we need not wonder that the *Lepidoptera* are excellent fliers. Indeed they seem to flit untired from flower to flower and from field to field; impelled at one

[a] Plate XXII. Fig. 7—. [b] Plate X. Fig. 6.
[c] De Geer, i. 173. *t.* x. *f.* 4. *Linn. Trans.* i. 135—.

while by hunger, and at another by love or maternal solicitude.—The distance to which some males will fly is astonishing. That of one of the silk-worm moths (*Bombyx Paphia*, F.) is stated to travel sometimes more than a hundred miles in this way[a].—Our most beautiful butterfly, the purple emperor (*Papilio Iris*, L.), when he makes his first appearance fixes his throne on the summit of some lofty oak, from whence in sunny days, unattended by his empress, who does not fly, he takes his excursions. Launching into the air from one of the highest twigs, he mounts often to so great a height as to become invisible. When the sun is at the meridian his loftiest flights take place; and about four in the afternoon he resumes his station of repose[b].—The large bodies of hawk-moths (*Sphinx*, F.) are carried by wings remarkably strong both as to nervures and texture, and their flight is proportionably rapid and direct. That of butterflies is by dipping and rising alternately, so as to form a zig-zag line with vertical angles, which the animal often describes with a skipping motion, so that each zig-zag consists of smaller ones. This doubtless renders it more difficult for the birds to take them as they fly; and thus the male, when paired, often flits away with the female.

Amongst the *Neuropterous* tribes the most conspicuous insects are the dragon-flies (*Libellulidæ*), which—their metamorphosis, habits, mode of life, and characters considered—form a distinct natural order of themselves. Their four wings, which are nearly equal in size, are a complete and beautiful piece of net-work, re-

[a] *Linn. Trans.* vii. 40.
[b] Haworth *Lepidopt. Brit.* i. 19.

sembling the finest lace, the meshes of which are usually filled by a pure, transparent, glassy membrane. In two of the genera belonging to this tribe, the wings, when the animal is at rest, are always expanded, so that they can take flight in an instant, no previous unfolding of these organs being necessary. In *Agrion*, the other genus of the tribe, the wings when they repose are not expanded. I have observed of these insects, and also of several others in different orders, that without turning they can fly in all directions—backwards, and to the right and left, as well as forwards. This ability to fly all ways, without having to turn, must be very useful to them when pursued by a bird. Leeuwenhoek once saw a swallow chasing an insect of this tribe, which he calls a *Mordella*, in a menagerie about a hundred feet long. The little creature flew with such astonishing velocity—to the right—to the left—and in all directions—that this bird of rapid wing and ready evolution was unable to overtake and entrap it; the insect eluding every attempt, and being generally six feet before it[a]. Indeed, such is the power of the long wings by which the dragon-flies are distinguished, particularly in *Æshna* and *Libellula*, and such the force of the muscles that move them, that they seem never to be wearied with flying. I have observed one of the former genus (*Anax Imperator*, Leach) sailing for hours over a piece of water—sometimes to and fro, and sometimes wheeling from side to side; and all the while chasing, capturing, and devouring the various insects that came athwart its course, or driving away its competitors—without ever seeming tired, or inclined to

[a] Leeuw. *Epist.* 6. Mart. 1717.

alight. Another species (*Æshna variegata*) very common in lanes and along hedges, which flies, like the *Orthoptera*, in a waving line, is equally alert and active after its prey. This, however, often alights for a moment, and then resumes its gay excursive flights. The species of the genus *Agrion* cut the air with less velocity; but so rapid is the motion of their wings, that they become quite invisible. Hawking always about for prey, the Agrions, from the variety of the colours of different individuals, form no uninteresting object during a summer stroll. With respect to the mode of flight of the other neuropterous tribes I have nothing to remark; for that of the *Ephemeræ*, which has been most noticed, I shall consider under another head.

The next order of insects, the *Hymenoptera*, attract also general attention as fliers, and from our earliest years. The ferocious hornet, with its trumpet of terror; the intrusive and indomitable wasp; the booming and pacific humble-bee, the frequent prey of merciless schoolboys; and that universal favourite, the industrious inhabitant of the hive,—all belonging to it,—are familiar to every one. And in summer-time there is scarcely a flower or leaf in field or garden, which is not visited by some of its numerous tribes. The four wings of these insects, the upper pair of which are larger than the under, vary much in their nervures. From the saw-flies (*Tenthredinidæ*), whose wings are nearly as much reticulated as those of some *Neuroptera*, to the minute *Chalcis* and *Psilus*, in which these organs are without nervures, there is every intermediate variety of reticulation that can be imagined[a]. It has been observed, that the nervures of

[a] Jurine *Hymenopt.* *t.* 2-5.

the wings are usually proportioned to the weight of the insect. Thus the saw-flies have generally bodies thicker than those of most other *Hymenoptera*, while those that have fewer nervures are more slender. This, however, does not hold good in all cases—so that the dimensions and cut of the wings, the strength of their nervures, and the force of their muscles, must also be taken into consideration. The wings of many of these insects when expanded, are kept in the same plane by means of small hooks (*Hamuli*) in the anterior margin of the under wing, which lay hold of the posterior margin of the upper[a]. Another peculiarity also distinguishes them. Base covers (*Tegulæ*), or small concavo-convex shields, protect the base of the wings from injury[b], or displacement.

The most powerful fliers in this order are the humble-bees, which, like the dung-chafers (*Geotrupes*), traverse the air in segments of a circle, the arc of which is alternately to right and left. The rapidity of their flight is so great, that could it be calculated, it would be found, the size of the creature considered, far to exceed that of any bird.—The aërial movements of the hive-bee are more direct and leisurely. When leaving the hive for an excursion, I have observed that as soon as they come out they turn about as if to survey the entrance, and then wheeling round in a circle, fly off. When they return to the hive, they often fly from side to side, as if to examine before they alight. When swarming, the heads of all are turned towards the group at the mouth of their dwelling; and upon rising into the air these little crea-

[a] Kirby, *Mon. Ap. Angl.* i. 96. 108. *t.* xiii. *f.* 19.
[b] Ibid. 96. 107. *t.* v. *f.* 8. *dd.*

tures fly so thick in every direction, as to appear like a kind of net-work with meshes of every angle. The queen also, upon going forth, when her object is to pair, after returning to reconnoitre, begins her flight by describing circles of considerable diameter, thus rising spirally with a rapid motion[a]. The object of these gyrations is probably to increase her chance of meeting with a drone.—I have not much to tell you with respect to the flight of other insects of this order, except that a spider-wasp (*Pompilus viaticus*, F.) whose sting is redoubtable, and which often, when we are in the vicinity of sandy sunny banks, accompanies our steps, has a kind of jumping movement when it flies.

The next order, the *Diptera*, consists altogether of two-winged flies:—but to replace the under wings of the tetrapterous insects, they are furnished with poisers, and numbers of them also with winglets. The poisers (*Halteres*) are little membranaceous threads placed one under the origin of each wing, near a spiracle, and terminated by an oval, round, or triangular button, which seems capable of dilatation and contraction. The animal moves these organs with great vivacity, often when at rest, and probably when flying. Their winglets (*Alulæ*) are different from those of *Dytiscus marginalis*, and the moth before noticed. Like them, they are of rigid membrane, and fringed; but they consist generally of two concavo-convex pieces (sometimes surrounded by a nervure), situated between the wing and the poisers, which, when the insect reposes, fold over each other like the valves of a bivalve shell; but when it flies they

[a] Huber, i. 38.

are extended. The use of neither of these organs seems to have been satisfactorily ascertained. Dr. Derham thinks they are for keeping the body steady in flight; and asserts, that if either a poiser or winglet be cut off, the insect will fly as if one side overbalanced the other, till it falls to the ground; and that if both be cut off, they will fly awkwardly and unsteadily, as if they had lost some very necessary part[a]. Shelver cut off the winglets of a fly, leaving both wings and poisers, but it could no longer fly. He next cut off the poisers of another, leaving the wings and winglets, and the same result followed. He found, upon removing one of these organs, that they were not properly compared to balancers. Observing that a common crane-fly (*Tipula crocata*) moved the knee of the hinder tibia in connexion with the wing and poiser, he cut it off, and it could no longer fly: this last experiment, however, seems contradicted by the fact, which has been often observed, that the insects of this genus will fly when half their legs are gone. He afterwards cut off both its poisers, when it could neither fly nor walk. Hence he conjectures that the poisers are connected with the feet, and are air-holders[b]. I have often seen flies move their poisers very briskly when at rest, particularly *Scioptera vibrans*, before mentioned. This renders Shelver's conjecture—that they are connected with respiration—not improbable. Perhaps by their action some effect may be produced upon the spiracle in their vicinity, either as to the opening or closing of it.

There are three classes of fliers in this order, the form

[a] *Phys. Theol.* 13th Ed. 366, note (*i.*)
[b] Wiedemann's *Archiv.* ii. 210—.

of whose bodies, as well as the shape and circumstances of their wings, is different. First are the slender flies—the gnats, gnat-like flies, and crane-flies (*Tipulidæ*). The bodies of these are light, their wings narrow, and their legs long, and they have no winglets. Next are those whose bodies, though slender, are more weighty—the *Asilidæ*, *Conopsidæ*, &c.; these have larger wings, shorter legs, and very minute and sometimes even obsolete winglets. Lastly come the flies, the *Muscidæ*, and their affinities, whose bodies being short, thick, and often very heavy, are furnished not only with proportionate wings and shorter legs, but also with conspicuous winglets. From these comparative differences and distinctions, we may conjecture in the first place—since the lightest bodies are furnished with the longest legs, and the heaviest with the shortest—that the legs act as poisers and rudders, that keep them steady while they fly, and assist them in directing their course[a]; and in the next—since the winglets are largest in the heaviest bodies, and altogether wanting in the lightest—that one of their principal uses is to assist the wings when the insect is flying.

The flight of the Tipulidan genera is very various. Sometimes, as I have observed, they fly up and down with a zig-zag course; at others in vertical curves of small diameter, like some birds; at others, again, in horizontal curves:—all these lines they describe with a kind of skipping motion. Sometimes they would seem to flit in every possible way—upwards, downwards, athwart, obliquely, and sometimes almost in circles. The common

[a] To those that frequent meadows and pastures (*Tipula oleracea*, L. &c.) they are also useful, as I have before observed, as stilts, to enable them to walk over the grass. Reaum. v. *Pref.* i. *t.* iii. *f.* 10.

gnat (*Culex pipiens*) seems to sail along also in various directions. The motion of its wings, if it does not fly like a hawk, is so rapid as not to be perceptible. When the crane-fly (*Tipula oleracea*) is upon the wing, its fore-legs are placed horizontally, pointing forwards, and the four hind ones stretched out in an opposite direction, the one forming the prow and the other the stern of the vessel, in its voyage through the ocean of air. The legs of another insect of this tribe (*Hirtæa Marci*) all point towards the anus in flight, the long anterior pair forming an acute angle with the body:—thus, perhaps, it can better cut the air.

I have often been amused in my walks with the motions of the hornet-fly (*Asilus crabroniformis*, L.), belonging to the second division just mentioned. This insect is carnivorous, living upon small flies. When you are taking your rambles, you may often observe it alight just before you;—as soon as you come up, it flies a little further, and will thus be your avant-courier for the whole length of a long field. This usually takes place, I seem to have observed, when a path lies under a hedge; and perhaps the object of this manœuvre may be the capture of prey. Your motions may drive a number of insects before you, and so be instrumental in supplying it with a meal. Other species of the genus have the same habit.

The aërial progress of the fly tribes (*Muscidæ*), including the gad-flies (*Œstrus*); horse-flies (*Tabanus*); carrion-flies (*Musca*), and many other genera—which constitute the heavy horse amongst our two-winged fliers—is wonderfully rapid, and usually in a direct line. An anonymous observer in Nicholson's *Journal*[a] calculates that, in

[a] 4to. iii. 36.

its ordinary flight, the common house-fly (*Musca domestica*, L.) makes with its wings about 600 strokes, which carry it five feet, every second. But if alarmed, he states their velocity can be increased six- or seven-fold, or to thirty or thirty-five feet, in the same period. In this space of time a race-horse could clear only ninety feet, which is at the rate of more than a mile in a minute. Our little fly, in her swiftest flight, will in the same space of time go more than the third of a mile. Now compare the infinite difference of the size of the two animals (ten millions of the fly would hardly counterpoise one racer), and how wonderful will the velocity of this minute creature appear! Did the fly equal the race-horse in size, and retain its present powers in the ratio of its magnitude, it would traverse the globe with the rapidity of lightning.

It seems to me, that it is not by muscular strength alone that many insects are enabled to keep so long upon the wing. Every one who attends to them must have noticed, that the velocity and duration of their flights depend much upon the heat or coolness of the atmosphere; especially the appearance of the sun. The warmer and more unclouded his beam, the more insects are there upon the wing, and every diurnal species seems fitted for longer or more frequent excursions. As these animals have no circulating fluid except the air in their tracheæ and bronchiæ, their locomotive powers, with few exceptions, must depend altogether upon the state of that element. When the thermometer descends below a certain point they become torpid, and when it reaches a certain height they revive; so that the air must be regarded, in some sense, as their blood, or rather the caloric that it contains; which when conveyed by the air, it circulates

quickly in them, invigorates all their motions, enters into the muscles and nervures of their wings, maintaining their tension, and by the greater or less rapidity of its pulsations accelerating or diminishing their action.

Having given you all the information that I can collect with respect to the motions of perfect insects in the *air*, I must next say something concerning their modes of locomotion in or upon the *water*. These are of two kinds, *swimming* and *walking*. Observe—I call that movement swimming, in which the animal pushes itself along by strokes—while in walking, the motion of the legs is not different from what it would be if they were on land. Most insects that *swim* have their posterior legs peculiarly fitted for it, either by a dense fringe of hairs on the shank and foot, as in the water-beetles (*Dytiscus*)[a], or the water-boatmen (*Notonecta*); or by having their terminal joints very much dilated—as in the whirlwig (*Gyrinus*)—so as to resemble the paddle of an oar[b]. When the Dytisci rise to the surface to take in fresh air—a silver bubble of which may often be seen suspended at their anus—they ascend, as it should seem, merely in consequence of their being specifically lighter than the water; but when they descend or move horizontally, which they do with considerable rapidity, it is by regular and successive strokes of their swimming legs. While they remain suspended at the surface, these legs are extended so as to form a right angle with their body. The *Notonectæ* swim upon their back, which enables

[a] Plate XIV. Fig. 6.

[b] Mr. Briggs observes that this insect appears to move all its legs at once, with wonderful rapidity, by which motion it produces a radiating vibration on the surface of the water.

them to see readily and seize the insects that fall upon the water, which are their prey. *Sigara*, however, a cognate genus separated from *Notonecta* by Fabricius, swims in the ordinary way. As the Gyrini are usually in motion at the surface, whirling round and round in circles, it is probable that their legs are best adapted to this movement. They dive down, however, with great ease and velocity when alarmed. The common water-bug (*Gerris lacustris*, Latr.), though it never goes under water, will sometimes swim upon the surface, which it does by strokes of the intermediate and posterior legs[a]. These, however, are neither fringed nor dilated, but very long and slender, with claws, not easily detected, situated under the apex of the last joint of the foot, which covers and conceals them. The underside of their body—as is the case with *Elophorus*, F., and many other aquatic insects—is clothed with a thick coat of gray hairs like satin, which in certain lights have no small degree of lustre, and protect its body from the effects of the water. Some insects, that are not naturally aquatic, if they fall into the water will swim very well. I once saw a kind of grasshopper (*Acrydiüm*, F.), which by the powerful strokes of its hind legs pushed itself across a stream with great rapidity.

Other insects *walk*, as it were, in the water, moving their legs much in the same way as they would do on the land. Many smaller species of water-beetles, belonging to the genera *Hydrophilus*, *Elophorus*, *Hydræna*, *Parnus*, *Elmis*, &c., thus win their way in the waves.—Thus also the water-scorpion (*Nepa*) pursues its prey; and the little water-mites (*Hydrachna*) may be seen in

[a] De Geer, iii. 314.

every pool thus working their little legs with great rapidity, and moving about in all directions.—Some spiders also will not only traverse the surface of the waters, but, as you have heard with respect to one[a], descend into their bosom. There are other insects moving in this way that are not divers. Of this kind are the aquatic bugs (*Gerris lacustris, Hydrometra Stagnorum, Velia Rivulorum*, &c., Latr.). The first can walk, run, and even leap, which it does upon its prey, as well as swim upon the surface. The second, remarkable for its extreme slenderness, and for its prominent hemispherical eyes—which, though they are really in the head, appear to be in the middle of the body—rambles about in chase of other insects, in considerable numbers, in most stagnant waters. The *Velia* is to be met with chiefly in running streams and rivers, coursing very rapidly over their waves. The two last species neither jump nor swim.

I am next to say a few words upon the motions of insects that *burrow*, either to conceal themselves or their young. Though burrowing is not always a locomotion, I shall consider it under this head, to preserve the unity of the subject. Many enter the earth by means of fore legs particularly formed for the purpose. The flat dentated anterior shanks, with slender feet, that distinguish the chafers (*Scarabæus*, L.)—all of which in their first states live under ground, and many occasionally in their last—enable them to make their way either into the earth or out of it. Two other genera of beetles (*Scarites* and *Clivina*, Latr.)[b] have these shanks palmated, or armed

[a] Vol. I. 4th Ed. 473. [b] Plate XV. Fig. 5.

with longer teeth at their extremity, for the same purpose. But the most remarkable burrower amongst perfect insects is that singular animal the mole-cricket (*Gryllotalpa vulgaris*, Latr.)[a]. This creature is endowed with wonderful strength, particularly in its thorax and fore legs. The former is a very hard and solid shell or crust, covering like a shield the trunk of the animal; and the latter are uncommonly fitted for burrowing, both by their strength and construction. The shanks are very broad, and terminate obliquely in four enormous sharp teeth[b], like so many fingers: the foot consists of three joints—the two first being broad and tooth-shaped, and pointing in an opposite direction to the teeth of the shank; and the last small, and armed at the extremity with two short claws. This foot is placed inside the shank, so as to resemble a thumb and perform the office of one[c]. The direction and motion of these hands, as in moles, is outwards; thus enabling the animal most effectually to remove the earth when it burrows. By the help of these powerful instruments, it is astonishing how instantaneously it buries itself. This creature works under ground like a field-mouse, raising a ridge as it goes; but it does not throw up heaps like its namesake the mole. They will in this manner undermine whole gardens; and thus in wet and swampy situations, in which they delight, they excavate their curious apartments, before described. —The field-cricket (*Acheta campestris*) is also a burrower, but by means of different instruments; for with its strong jaws, toothed like the claws of a lobster, but sharper, in heaths and other dry situations it perforates

[a] Plate II. Fig. 2. [b] Plate XV. Fig. 6. *a*. [c] Ibid. *b*.

and rounds its curious and regular cells. The house-cricket (*A. domestica*), which, on account of the softness of the mortar, delights in new-built houses, with the same organs, to make herself a covered-way from room to room, burrows and mines between the joints of the bricks and stones[a].

But of all the burrowing tribes, none are so numerous as those of the order *Hymenoptera*. Wherever you see a bare bank, of a sunny exposure, you always find it full of the habitations of insects belonging to it;—and besides this, every rail and old piece of timber is with the same view perforated by them. Bees; wasps; bee-wasps (*Bembex*); spider-wasps (*Pompilus*); fly-wasps (*Mellinus, Cerceris, Crabro*), with many others, excavate subterranean or ligneous habitations for their young. None is more remarkable in this respect than the sand-wasp (*Ammophila*, K.), or as it might be better named—since it always commits its eggs to caterpillars which it inhumes—the caterpillar-wasp. It digs its burrows, by scratching with its fore legs like a dog or a rabbit, dispersing with its hind ones, which are particularly constructed for that purpose, the sand so collected[b].

Since most of these burrows are designed for the reception of the eggs of the burrowers, I shall next describe to you the manner in which one of the long-legged gnats, or crane-flies (*Tipula variegata*, L.)—a proceeding to which I was myself a witness—oviposits. Choosing a south bank bare of grass, she stood with her legs stretched out on each side, and kept turning herself half round

[a] White, *Nat. Hist.* ii. 80. 72. 76. [b] *Linn. Trans.* iv. 200—.

backwards and forwards alternately. Thus the ovipositor, which terminates her long cylindrical pointed abdomen, made its way into the hard soil, and deposited her eggs in a secure situation. All, however, were not committed to the same burrow; for she every now and then shifted her station, but not more than an inch from where she bored last. While she was thus engaged, I observed her male companion suspended by one of his legs on a twig, not far from her. The common turf-boring crane-fly (*T. oleracea*, L.), when engaged in laying eggs, moves over the grass with her body in a vertical position, by the help—her four anterior legs being in the air—of her two posterior ones, and the end of her abdomen, which performs the office of another. Whether in boring, like *T. variegata*, she turns half round and back, does not appear from Reaumur's account[a].

I now come to motions whose object seems to be *sport* and amusement rather than locomotion. They may be considered as of three kinds—hovering—gyrations—and dancing.

You have often in the woods and other places seen flies suspended as it were in the air, their wings all the while moving so rapidly as to be almost invisible. This *hovering*, which seems peculiar to the aphidivorous flies, has been also noticed by De Geer[b]. I have frequently amused myself with watching them; but when I have endeavoured to entrap them with my forceps, they have immediately shifted their quarters, and resumed their amusement elsewhere. The most remarkable insects in this respect are the sphinxes, and from this they doubt-

[a] v. 20—. [b] vi. 104.

less took their name of *hawk-moths*. When they unfold their long tongue, and wipe its sweets from any nectariferous flower, they always keep upon the wing, suspending themselves over it till they have exhausted them, when they fly away to another. The species called by collectors the humming-bird (*S. Stellatarum*, L.), and by some persons mistaken for a real one, is remarkable for this, and the motion of its wings is inconceivably rapid[a].

The *gyrations* of insects take place either when they are reposing, or when they are flying or swimming.— I was once much diverted by observing the actions of a minute moth (*Tinea*) upon a leaf on which it was stationed. Making its head the centre of its revolutions, it turned round and round with considerable rapidity, as if it had the vertigo, for some time. I did not, however, succeed in my attempts to take it.—Scaliger noticed a similar motion in the book-crab (*Chelifer cancroides*)[b].

Reaumur describes in a very interesting and lively way the gyrations of the Ephemeræ before noticed[c], round a lighted flambeau. It is singular, says he, that moths which fly only in the night, and shun the day, should be precisely those that come to seek the light in our apartments. It is still more extraordinary that these Ephemeræ—which appearing after sun-set, and dying before sun-rise, are destined never to behold the light of that orb—should have so strong an inclination for any luminous object. To hold a flambeau when they ap-

[a] Rai. *Hist. Ins.* 133. 1. [b] Lesser, *L.* i. 248, note 22.
[c] Vol. I. 4th Ed. 282—.

peared was no very pleasant office; for he who filled it, in a few seconds had his dress covered with the insects, which rushed from all quarters to him. The light of the flambeau exhibited a spectacle which enchanted every one that beheld it. All that were present, even the most ignorant and stupid of his domestics, were never satisfied with looking at it. Never had any armillary sphere so many zones, as there were here circles, which had the light for their centre. There was an infinity of them—crossing each other in all directions, and of every imaginable inclination—all of which were more or less eccentric. Each zone was composed of an unbroken string of Ephemeræ, resembling a piece of silver lace formed into a circle deeply notched, and consisting of equal triangles placed end to end (so that one of the angles of that which followed touched the middle of the base of that which preceded), and moving with astonishing rapidity. The wings of the flies, which was all of them that could then be distinguished, formed this appearance. Each of these creatures, after having described one or two orbits, fell upon the earth or into the water, but not in consequence of being burned[a]. Reaumur was one of the most accurate of observers; and yet I suspect that the appearance he describes was a visual deception, and for the following reason. I was once walking in the day-time with a friend[b], when our attention was caught by myriads of small flies, which were dancing under every tree;—viewed in a certain light

[a] Reaum. vi. 484. *t.* xlv. *f.* 7.

[b] The persons observing the appearance here related were the authors of this work.

they appeared a concatenated series of insects (as Reaumur has here described his Ephemeræ) moving in a spiral direction upwards ;—but each series, upon close examination, we found was produced by the astonishingly rapid movement of a single fly. Indeed, when we consider the space that a fly will pass through in a second, it is not wonderful that the eye should be unable to trace its gradual progress, or that it should appear present in the whole space at the same instant. The fly we saw was a small male Ichneumon.

Other circular motions of sportive insects take place in the waters. Linné, in his Lapland tour, noticed a black Tipula which ran over the water, and turned round like a Gyrinus [a]. This last insect I have often mentioned;—it seems the merriest and most agile of all the inhabitants of the waves. Wonderful is the velocity with which they turn round and round, as it were, pursuing each other in incessant circles, sometimes moving in oblique, and indeed in every other direction. Now and then they repose on the surface, as if fatigued with their dances, and desirous of enjoying the full effect of the sun-beam: if you approach, they are instantaneously in motion again. Attempt to entrap them with your net, and they are under the water and dispersed in a moment. When the danger ceases they re-appear and resume their vagaries. Covered with lucid armour, when the sun shines they look like little dancing masses of silver or brilliant pearls [b].

But the motions of this kind to which I particularly

[a] *Lach. Lapp.* i. 194.

[b] Compare Oliv. *Entomol.* iii. *Gyrinus* 4.

wish to call your attention, are the choral dances of males in the air; for the dancing sex amongst insects is the masculine, the ladies generally keeping themselves quiet at home. These dances occur at all seasons of the year, both in winter and summer, though in the former season they are confined to the hardy Tipulidæ. In the morning before twelve, the *Hopliæ*, root-beetles before mentioned, have their dances in the air, and the solstitial and common cockchafer appear in the evening—the former generally coming forth at the summer solstice—and fill the air over the trees and hedges with their myriads and their hum. Other dancing insects resemble moving columns—each individual rising and falling in a vertical line a certain space, and which will follow the passing traveller—often intent upon other business, and all-unconscious of his aërial companions—for a considerable distance.

Towards sun-set the common Ephemeræ (*E. vulgata*, L.), distinguished by their spotted wings and three long tails (*Caudulæ*), commence their dances in the meadows near the rivers. They assemble in troops, consisting sometimes of several hundreds, and keep rising and falling continually, usually over some high tree. They rise beating the air rapidly with their wings, till they have ascended five or six feet above the tree; then they descend to it with their wings extended and motionless, sailing like hawks, and having their three tails elevated, and the lateral ones so separated as to form nearly a right angle with the central one. These tails seem given them to balance their bodies when they descend, which they do in a horizontal position. This motion continues

two or three hours without ceasing, and commences in fine clear weather about an hour before sun-set, lasting till the copious falling of the dew compels them to retire to their nocturnal station[a]. Our most common species, which I have usually taken for the *E. vulgata*, varies from that of De Geer in its proceedings. I found them at the end of May dancing over the meadows, not over the trees, at a much earlier hour—at half-past three—rising in the way just described, about a foot, and then descending, at the distance of about four or five feet from the ground. Another species, common here, rises seven or eight feet. I have also seen Ephemeræ flying over the water in a horizontal direction. The females are sometimes in the air, when the males seize them, and they fly paired. These insects seem to use their fore legs to break the air; they are applied together before the head, and look like antennæ.—*Empis maura*, a little beaked fly, I have observed rushing in infinite numbers like a shower of rain driven by the wind, as before observed[b], over waters, and then returning back.

It is remarkable that the smaller *Tipulidæ* will fly unwetted in a heavy shower of rain, as I have often observed. How keen must be their sight, and how rapid their motions, to enable them to steer between drops bigger than their own bodies, which, if they fell upon them, must dash them to the ground!

Amidst this infinite variety of motions, for purposes so numerous and diversified, and performed by such a multiplicity of instruments and organs, who does not

[a] De Geer, ii. 638—. [b] See above, p. 7.

discern and adore the Great First Mover? From him all proceed, by him all are endowed, in him all move: and it is to accomplish his ends, and to go on his errands, that these little but not insignificant beings are thus gifted; since it is by them that he maintains this terraqueous globe in order and beauty, thus rendering it fit for the residence of his creature man.

I am, &c.

LETTER XXIV.

ON THE NOISES PRODUCED BY INSECTS.

THAT insects, though they fill the air with a variety of sounds, have no *voice*, may seem to you a paradox, and you may be tempted to exclaim with the Roman naturalist, What, amidst this incessant diurnal hum of bees; this evening boom of beetles; this nocturnal buz of gnats; this merry chirp of crickets and grasshoppers; this deafening drum of Cicadæ, have insects no voice! If by voice we understand sounds produced by the air expelled from the lungs, which, passing through the larynx, is modified by the tongue, and emitted from the mouth,—it is even so. For no insect, like the larger animals, uses its mouth for utterance of any kind: in this respect they are all perfectly mute; and though incessantly noisy, are everlastingly silent. Of this fact the Stagyrite was not ignorant, since, denying them a voice, he attributes the sounds emitted by insects to another cause. But if we feel disposed to give a larger extent to this word; if we are of opinion that all sounds, however produced, by means of which animals determine those of their own species to certain actions, merit the

name of voice; then I will grant that insects have a voice. But, decide this question as we will, we all know that by some means or other, at certain seasons and on various occasions, these little creatures make a great din in the world. I must therefore now bespeak your attention to this department of their history.

In discussing this subject, I shall consider the noises insects emit—during their motions—when they are feeding, or otherwise employed—when they are calling or commanding—or when they are under the influence of the passions; of fear, of anger, of sorrow, joy, or love.

The only kind of *locomotion* during which these animals produce sounds, is flying: for though the hill-ants (*Formica rufa*, L.), as I formerly observed[a], make a rustling noise with their feet when walking over dry leaves, I know of no other insect the tread of which is accompanied by sound—except indeed the flea, whose steps, a lady assures me, she always hears when it paces over her night-cap, and that it clicks as if it was walking in pattens! That the flight of numbers of insects is attended by a humming or booming is known to almost every one; but that the great majority move through the air in silence, has not perhaps been so often observed. Generally speaking, those that fly with the most force and rapidity, and with wings seemingly motionless, make the most noise; while those that fly gently and leisurely, and visibly fan the air with their wings, yield little or no sound.

Amongst the beetle tribes (*Coleoptera*), none is more noticed, or more celebrated for "wheeling its droning

[a] See above, p. 97.

flight," than the common dung-chafer (*Geotrupes stercorarius*) and its affinities. Linné affirms—but the prognostic sometimes fails—that when these insects fly in numbers, it indicates a subsequent fine day[a]. The truth is, they only fly in fine weather. Mr. White has remarked, that in the dusk of the evening beetles begin to buz, and that partridges begin to call exactly at the same time[b]. The common cockchafer, and that which appears at the summer solstice (*Melolontha vulgaris* and *solstitialis*, F.), when they hover over the summits of trees in numbers, produce a hum somewhat resembling that of bees swarming. Perhaps some insect of this kind may occasion the humming in the air mentioned by Mr. White, and which you and I have often heard in other places. "There is," says he, "a natural occurrence to be met with in the highest part of our down on the hot summer days, which always amuses me much, without giving me any satisfaction with respect to the cause of it;—and that is a loud audible humming of bees in the air, though not one insect is to be seen.——Any person would suppose that a large swarm of bees was in motion, and playing about over his head[c]."

"Resounds the living surface of the ground—
Nor undelightful is the ceaseless hum
To him who muses through the woods at noon,
Or drowsy shepherd as he lies reclined."

The hotter the weather, the higher insects will soar; and it is not improbable that the sound produced by numbers may be heard, when those that produce it are out of sight.—The burying-beetle (*Necrophorus Vespillo*,

[a] *Syst. Nat.* 550. 42. [b] *Nat. Hist.* ii. 254.
[c] White, *Nat. Hist.* ii. 256.

F.), whose singular history[a] so much amused you, as well as *Cicindela sylvatica* of the same order, flies likewise, as I have more than once witnessed, with a considerable hum.

Whether the innumerable locust armies, to which I have so often called your attention, make any noise in their flight, I have not been able to ascertain; the mere impulse of the wings of myriads and myriads of these creatures upon the air, must, one would think, produce some sound. In the symbolical locusts mentioned in the Apocalypse[b], this is compared to the sound of chariots rushing to battle: an illustration which the inspired author of that book would scarcely have had recourse to, if the real locusts winged their way in silence.

Amongst the *Hemiptera*, I know only a single species that is of noisy flight; though doubtless, were the attention of entomologists directed to that object, others would be found exhibiting the same peculiarity. The insect I allude to (*Coreus marginatus*, F.) is one of the numerous tribe of bugs; when flying, especially when hovering together in a sunny sheltered spot, they emit a hum as loud as that of the hive-bee.

From the magnitude and strength of their wings, it might be supposed that many *lepidopterous* insects would not be silent in their flight;—and indeed many of the hawk-moths (*Sphinx*, F.), and some of the larger moths (*Bombyx*, F.), are not so; *B. Cossus*, for instance, is said to emulate the booming of beetles by means of its large stiff wings; whence in Germany it is called the humming-bird (*Brumm-Vogel*).—But the great body of these

[a] Vol. I. 4th Ed. 350— [b] Rev. ix. 9.

numerous tribes, even those that fan the air with "sail-broad vans," produce little or no sound by their motion. I must therefore leave them, as well as the *Trichoptera* and *Neuroptera*, which are equally barren of insects of sounding wing—and proceed to an order, the *Hymenoptera*, in which the insects that compose it are, many of them, of more fame for this property.

The indefatigable hive-bee, as she flies from flower to flower, amuses the observer with her hum, which, though monotonous, pleases by exciting the idea of happy industry, that wiles the toils of labour with a song. When she alights upon a flower, and is engaged in collecting its sweets, her hum ceases; but it is resumed again the moment that she leaves it.—The wasp and hornet also are strenuous hummers; and when they enter our apartments, their hum often brings terror with it. But the most sonorous fliers of this order are the larger humble-bees, whose *bombination*, *booming*, or *bombing*, may be heard from a considerable distance, gradually increasing as the animal approaches you, and when, in its wheeling flight, it rudely passes close to your ear, almost stunning you by its sharp, shrill, and deafening sound. Many genera, however, of this order fly silently.

But the noisiest wings belong to insects of the *dipterous* order, a majority of which, probably, give notice of their approach by the sound of their trumpets. Most of those, however, that have a slender body,—the gnat genus (*Culex*) excepted,—explore the air in silence. Of this description are the *Tipulidæ*, the *Asilidæ*, the genus *Empis*, and their affinities. The rest are more or less insects of a humming flight; and with respect to

many of them, their hum is a sound of terror and dismay to those who hear it. To man, the trumpet of the gnat or mosquito; and to beasts, that of the gad-fly; the various kinds of horse flies (*Tabanus*, *Stomoxys*, *Hippobosca*); and of the Ethiopian zimb, as I have before related at large[a], is the signal of intolerable annoyance. Homer, in his *Batrachomyomachia*, long ago celebrated the first of these as a trumpeter—

> "For their sonorous trumpets far renown'd,
> Of battle the dire charge mosquitos sound."

Mr. Pope, in his translation, with his usual inaccuracy, thinking no doubt to improve upon his author, has turned the old bard's gnats into hornets. In Guiana these animals are distinguished by a name still more tremendous, being called the devil's trumpeters[b]. I have observed that early in the spring, before their thirst for blood seizes them, gnats when flying emit no sound. At this moment (Feb. 18th) two females are flying about my windows in perfect silence.

After this short account of insects that give notice when they are upon the wing by the sounds that precede them, I must inquire by what means these sounds are produced. Ordinarily, except perhaps in the case of the gnat, they seem perfectly independent of the will of the animal; and in almost every instance, the sole instruments that cause the noise of flying insects are their wings, or some parts near to them, which, by their friction against the trunk, occasion a vibration—as the fingers upon the strings of a guitar—yielding a sound more or less acute in proportion to the rapidity of their

[a] Vol. I. 4th Ed. 113. 146—. [b] Stedman's *Surinam*, i. 24.

flight—the action of the air perhaps upon these organs giving it some modifications. Whether, in the beetles that fly with noise, the elytra contribute more or less to produce it, seems not to have been clearly ascertained: yet, since they fly with force as well as velocity, the action of the air may cause some motion in them, enough to occasion friction. With respect to *Diptera*, Latreille contends that the noise of flies on the wing cannot be the result of friction, because their wings are then expanded; but though to us flies seem to sail through the air without moving these organs, yet they are doubtless all the while in motion, though too rapid for the eye to perceive it. When the aphidivorous flies are hovering, the vertical play of their wings, though very rapid, is easily seen; but when they fly off it is no longer visible. Repeated experiments have been tried to ascertain the cause of sound in this tribe, but it should seem with different results. De Geer, whose observations were made upon one of the flies just mentioned, appears to have proved that, in the insect he examined, the sounds were produced by the friction of the root or base of the wings against the sides of the cavity in which they are inserted. To be convinced of this, he affirms, the observer has nothing to do but to hold each wing with the finger and thumb, and stretching them out, taking care not to hurt the animal, in opposite directions, thus to prevent their motion,—and immediately all sound will cease. For further satisfaction he made the following experiment. He first cut off the wings of one of these flies very near the base; but finding that it still continued to buz as before, he thought that the winglets and poisers, which he remarked were in a constant vibration,

might occasion the sound. Upon this, cutting both off, he examined the mutilated fly with a microscope, and found that the remaining fragments of the wings were in constant motion all the time that the buzzing continued; but that upon pulling them up by the roots all sound ceased[a]. Shelver's experiments, noticed in my last letter, go to prove, with respect to the insects that he examined, that the winglets are more particularly concerned with the buzzing. Upon cutting off the wings of a fly—but he does not state that he pulled them up by the roots—he found the sound continued. He next cut off the poisers—the buzzing went on. This experiment was repeated eighteen times with the same result. Lastly, when he took off the winglets, either wholly or partially, the buzzing ceased. This, however, if correct, can only be a cause of this noise in the insects that have winglets. Numbers have them not. He next, therefore, cut off the poisers of a crane-fly (*Tipula crocata*, L.), and found that it buzzed when it moved the wing. He cut off half the latter, yet still the sound continued; but when he had cut off the whole of these organs the sound entirely ceased[b].

Aristophanes in his *Clouds*, deriding Socrates, introduces Chærephon as asking that philosopher whether gnats made their buz with their mouth or their tail[c]. Upon which Mouffet very gravely observes, that the sound of one of these insects approaching is much more acute than that of one retiring; from whence he very sapiently concludes, that not the tail but the mouth must be their organ of sound[d]. But after all, the fric-

[a] De Geer, vi. 13.
[b] Wiedemann's *Archiv.* ii. 210. 217.
[c] *Act.* i. *Sc.* 2.
[d] Mouffet, 81.

tion of the base of the wings against the thorax seems to be the sole cause of the alarming buz of the gnat as well as that of other *Diptera*. The warmer the weather, the greater is their thirst for blood, the more forcible their flight, the motion of their wings more rapid, and the sound produced by that motion more intense. In the night—but perhaps this may arise from the universal stillness that then reigns—their hum appears louder than in the day: whence its tones may seem to be modified by the will of the animal.

Sounds also are sometimes emitted by insects when they are *feeding* or otherwise *employed*. The action of the jaws of a large number of cockchafers produces a noise resembling the sawing of timber; that of the locusts has been compared to the crackling of a flame of fire driven by the wind; indeed the collision at the same instant of myriads of millions of their powerful jaws must be attended by a considerable sound. The timber-borers also—the *Buprestes*; the stag-horn beetles (*Lucani*); and particularly the capricorn-beetles (*Cerambycidæ*)—the mandibles of whose larvæ resemble a pair of mill-stones[a]—most probably do not feed in silence. A little wood-louse (*Psocus pulsatorius*, Latr.)—which on that account has been confounded with the death-watch—is said also, when so engaged, to emit a ticking noise.—Certain two-winged flies seen in spring, distinguished by a very long proboscis (*Bombylius*, L.), hum all the time that they suck the honey from the flowers; as do also many hawk-moths, particularly that called from this circumstance the humming-bird (*Sphinx*

[a] *Linn. Trans.* v. 255. *t.* xii. *f.* 7. b.

Stellatarum, L.), which, while it hovers over them, unfolding its long tongue, pilfers their sweets without interrupting its song.—The giant cock-roach (*Blatta gigantea*, L.), which abounds in old timber houses in the warmer parts of the world, makes a noise when the family are asleep like a pretty smart rapping with the knuckles—three or four sometimes appearing to answer each other.—On this account in the West Indies it is called the *Drummer;* and they sometimes beat such a reveille, that only good sleepers can rest for them[a]. As the animals of this genus generally come forth in the night for the purpose of feeding, this noise is probably connected with that subject.

Insects also, at least many of the social ones, emit peculiar noises while engaged in their various *employments.* If an ear be applied to a wasps or humble-bees nest, or a bee-hive, a hum more or less intense may always be perceived. Were I disposed to play upon your credulity, I might tell you, with Gœdart, that in every humble-bees nest there is a trumpeter, who early in the morning, ascending to its summit, vibrates his wings, and sounding his trumpet for the space of a quarter of an hour, rouses the inhabitants to work! But since Reaumur could never witness this, I shall not insist upon your believing it, though the relater declares that he had heard it with his ears, and seen it with his eyes, and had called many to witness the vibrating and strepent wings of this trumpeter humble-bee[b].—The blue sand-wasp (*Ammophila cyanea*), which at all other times is silent, when engaged in building its cells emits a singular

[a] Drury's *Insects*, iii. Preface.

[b] Lister's *Gœdart*, 244—. Compare Reaum. vi. 30.

but pleasing sound, which may be heard at ten or twelve yards distance[a].

Some insects also are remarkable for a peculiar mode of *calling*, *commanding*, or giving an *alarm*. I have before mentioned the noise made by the neuters or soldiers amongst the white ants, by which they keep the labourers, who answer it by a hiss, upon the alert and to their work[b]. This noise, which is produced by striking any substance with their mandibles, Smeathman describes as a small vibrating sound, rather shriller and quicker than the ticking of a watch. It could be distinguished, he says, at the distance of three or four feet, and continued for a minute at a time with very short intervals. When any one walks in a solitary grove, where the covered ways of these insects abound, they give the alarm by a loud hissing, which is heard at every step[c].—"When house-crickets are out," says Mr. White, "and running about in a room in the night, if surprised by a candle they give two or three shrill notes, as it were for a signal to their followers, that they may escape to their crannies and lurking-holes to avoid danger[d]."

Under this head I shall consider a noise before alluded to[e], which has been a cause of alarm and terror to the superstitious in all ages. You will perceive that I am speaking of the death-watch—so called, because it emits a sound resembling the ticking of a watch, supposed to predict the death of some one of the family in the house in which it is heard Thus sings the muse of the witty Dean of St. Patrick on this subject:

[a] Bingley, *Animal Biogr.* iii. 1st Ed. 335. [b] See above, p. 41.
[c] *Philos. Trans.* 1781. 48. 38. [d] *Nat. Hist.* ii. 262.
[e] Vol. I. 4th Ed. p. 36.

"......................A wood-worm
That lies in old wood, like a hare in her form:
With teeth or with claws it will bite or will scratch,
And chambermaids christen this worm a death-watch:
Because like a watch it always cries click;
Then woe be to those in the house who are sick!
For, sure as a gun, they will give up the ghost,
If the maggot cries click, when it scratches the post:
But a kettle of scalding hot water injected,
Infallibly cures the timber affected:
The omen is broken, the danger is over,
The maggot will die, and the sick will recover."

To add to the effect of this noise, it is said to be made only when there is a profound silence in an apartment, and every one is still.

Authors were formerly not agreed concerning the insect from which this sound of terror proceeded, some attributing it to a kind of wood-louse, as I lately observed, and others to a spider; but it is a received opinion now, adopted upon satisfactory evidence, that it is produced by some little beetles belonging to the timber-boring genus *Anobium*, F. Swammerdam observes, that a small beetle, which he had in his collection, having firmly fixed its fore legs, and put its inflexed head between them, makes a continual noise in old pieces of wood, walls, and ceilings, which is sometimes so loud, that upon hearing it, people have fancied that hobgoblins, ghosts, or fairies were wandering around them[a]. Evidently this was one of the death-watches. Latreille observed *Anobium striatum*, F. produce the sound in question by a stroke of its mandibles upon the wood, which was answered by a si-

[a] *Bibl. Nat.* Ed. Hill, i. 125.

milar noise from within it. But the species whose proceedings have been most noticed by British observers is *A. tessellatum*, F. When spring is far advanced, these insects are said to commence their ticking, which is only a call to each other, to which if no answer be returned, the animal repeats it in another place. It is thus produced. Raising itself upon its hind legs, with the body somewhat inclined, it beats its head with great force and agility upon the plane of position; and its strokes are so powerful as to make a considerable impression if they fall upon any substance softer than wood. The general number of distinct strokes in succession is from seven to nine or eleven. They follow each other quickly, and are repeated at uncertain intervals. In old houses, were these insects abound, they may be heard in warm weather during the whole day. The noise exactly resembles that produced by tapping moderately with the nail upon the table; and when familiarized, the insect will answer very readily the tap of the nail[a].

The queen bee has long been celebrated for a peculiar sound, producing the most extraordinary effects upon her subjects. Sometimes, just before bees swarm,—instead of the great hum usually heard, and even in the night,—if the ear be placed close to the mouth of the hive, a sharp clear sound may be distinguished, which appears to be produced by the vibration of the wings of a single bee. This, it has been pretended, is the harangue of the new queen to her subjects, to inspire them with courage to achieve the foundation of a new empire. But Butler

[a] Shaw's *Nat. Misc.* iii. 104. *Phil. Trans.* xxxiii. 159. Compare Dumeril *Traité Element.* ii. 91. n. 694.

gives to it a different interpretation. He asserts, that the candidate for the new throne is then with earnest entreaties, lamentations, and groans, supplicating the queen-mother of the hive to grant her permission to lead the intended colony;—that this is continued, before she can obtain her consent, for two days; when the old queen relenting gives her fiat in a fuller and stronger tone. That should the former presume to imitate the tones of the sovereign, this being the signal of revolt, she would be executed on the spot, with all whom she had seduced from their loyalty[a].—But it is time to leave fables: I shall therefore next relate to you what really takes place. You have heard how the bees detain their young queens till they are fit to lead a swarm.—I then mentioned the attitude and sound that strike the former motionless[b]. When she emits this authoritative sound, reclining her thorax against a comb, the queen stands with her wings crossed upon her back, which, without being uncrossed or further expanded, are kept in constant vibration. The tone thus produced is a very distinct kind of clicking, composed of many notes in the same key, which follow each other rapidly. This sound the queens emit before they are permitted to leave their cells; but it does not then seem to affect the bees. But when once they are liberated from confinement and assume the above attitude, its effects upon them are very remarkable. As soon as the sound was heard, Huber tells us, bees that had been employed in plucking, biting, and chasing a queen about, hung down their heads and remained altogether motion-

[a] Reaum. v. 615. Butler's *Female Monarchy*, c. v. § 4.
[b] See above, p. 149—.

less; and whenever she had recourse to this attitude and sound, they operated upon them in the same manner. The writer just mentioned observed differences both with regard to the succession and intensity of the notes and tones of this royal song; and, as he justly remarks, there may be still finer shades which, escaping our organs, may be distinctly perceived by the bees[a]. He seems however to doubt by what means this sound is produced. Reasoning analogically, the motion of the wings should occasion it. We have seen that they are in constant motion when it is uttered. Probably the intensity of the tones and their succession are regulated by the intensity of the vibrations of the wings. Reaumur remarks, that the different tones of the bees, whether more or less grave or acute, are produced by the strokes, more or less rapid, of their wings against the air, and that perhaps their different angles of inclination may vary the sound. The friction of their bases likewise against the sides of the cavity in which they are inserted, as in the case of the fly lately mentioned, or against the base-covers (*Tegulæ*), may produce or modulate their sounds, a bee whose wings are eradicated being perfectly mute[b]. This last assertion, however, is contradicted by John Hunter, who affirms that bees produce a noise independent of their wings, emitting a shrill and peevish sound though they are cut off, and the legs held fast[c]. Yet it does not appear from his experiment that the wings were eradicated. And if they were only cut off, the friction of their base might cause the sound. I have before noticed the remarkable fact, that the queens educated according to M. Schirach's

[a] Huber, i. 260. ii. 292—. [b] Reaum. v. 617.
[c] *Philos. Trans.* 1792.

method are absolutely mute; on which account the bees keep no guard around their cells, nor retain them an instant in them after their transformation [a].

The *passions*, also, which urge us to various exclamations, elicit from insects occasionally certain sounds. Fear, anger, sorrow, joy, or love and desire, they express in particular instances by particular noises. I shall begin with those which they emit when under any *alarm*. One *larva* only is recorded as uttering a cry of alarm, and it produces a perfect insect remarkable for the same faculty: I allude to *Sphinx Atropos*. Its caterpillar, if disturbed at all, draws back rapidly, making at the same time a rather loud noise, which has been compared to the crack of an electric spark [b].—You would scarcely think that any *quiescent pupæ* could show their fears by a sound,—yet in one instance this appears to be the case. De Geer having made a small incision in the cocoon of a moth, which included that of its parasite Ichneumon (*I. Cantator*, De G.), the insect concealed within the latter uttered a little cry, similar to the chirping of a small grasshopper, continuing it for a long time together. The sound was produced by the friction of its body against the elastic substance of its own cocoon, and was easily imitated by rubbing a knife against its surface [c].

But to come to *perfect* insects. Many beetles when taken show their alarm by the emission of a shrill, sibilant, or creaking sound—which some compare to the chirping of young birds—produced by rubbing their elytra with the extremity of their abdomen. This is the case with the dung-chafers (*Scarabæus vernalis, stercora-*

[a] Huber, i. 292— [b] Fuessl. *Archiv.* 8. 10. [c] De Geer, vii. 594.

rius, and *Copris lunaris*); with the carrion-chafer (*Trox sabulosus*); and others of the *Scarabæidæ*. The burying-beetle (*Necrophorus Vespillo*), *Auchenia melanopa*, E. B., *Crioceris merdigera*, and *Dytiscus Hermanni*, and many other *Coleoptera*, produce a similar noise by the same means. When this noise is made, the movement of the abdomen may be perceived; and if a pin is introduced under the elytra it ceases. Long after many of these insects are dead the noise may be caused by pressure. Rösel found this with respect to the *Scarabæidæ*[a], and I have repeated the experiment with success upon *Necrophorus Vespillo*. The capricorn tribes (*Cerambycidæ*) emit under alarm an acute or creaking sound—which Lister calls querulous, and Dumeril compares to the braying of an ass[b]—by the friction of the thorax, which they alternately elevate and depress, against the neck, and sometimes against the base of the elytra[c]. On account of this, *Prionus coriarius*, F. is called *the fiddler* in Germany[d]. Two other coleopterous genera, *Cychrus* and *Clytus*, make their cry of *Noli me tangere* by rubbing their thorax against the base of the elytra. *Pimelia*, another beetle, does the same by the friction of its legs against each other[e]. And, doubtless, many more *Coleoptera*, if observed, would be found to express their fears by similar means.

In the other orders the examples of cries of terror are much less numerous. A bug (*Cimex subapterus*, De G.) when taken emits a sharp sound, probably with its rostrum, by moving its head up and down[f]. Ray makes

[a] Rösel, II. 208.
[b] Raii *Hist. Ins.* 384. Dumeril. *Trait. Element.* ii. 100. n. 17.
[c] De Geer, v. 58. 69. Rösel, II. iii. 5. [d] Rösel, ibid.
[e] Latr. *Hist. Nat.* x. 264. [f] De Geer, iii. 289.

a similar remark with respect to another bug (*Reduvius personatus*, F.), the cry of which he compares to the chirping of a grasshopper[a]. *Mutilla europæa*, a hymenopterous insect, makes a sibilant chirping, as I once observed at Southwold, where it abounds; but how produced I cannot say. The most remarkable noise, however, proceeding from insects under alarm, is that emitted by the death's-head hawk-moth, and for which it has long been celebrated. The *Lepidoptera*, though some of them, as we have seen, produce a sound when they fly, at other times are usually mute insects: but this alarmist—for so it may be called, from the terrors which it has occasioned to the superstitious[b]—when it walks, and more particularly when it is confined, or taken into the hand, sends forth a strong and sharp cry, resembling that of a mouse, but more plaintive, and even lamentable, which it continues as long as it is held. This cry does not appear to be produced by the wings; for when they, as well as the thorax and abdomen, are held down, the cries of the insect become still louder. Schrœter says that the animal, when it utters its cry, rubs its tongue against its head[c]; and Rösel, that it produces it by the friction of the thorax and abdomen[d]. But Reaumur found, after the most attentive examination, that the cry came from the mouth, or rather from the tongue; and he thought that it was produced by the friction of the palpi against that organ. When, by means of a pin, he unfolded the spiral tongue, the cry ceased; but as soon as it was rolled up again between the palpi it was renewed. He next prevented the palpi from touching it, and the

[a] *Hist. Ins.* 56.
[b] Vol. I. 4th Ed. 34.
[c] *Naturforscher* Stk. xxi. 77.
[d] III. 16.

sound also ceased; and upon removing only one of them, though it continued, it became much more feeble[a]. Huber, however, denies that it is produced by the friction of the tongue and palpi[b]: but, as he has not stated his reasons for this opinion, I think his assertion that he has ascertained this cannot be allowed to countervail Reaumur's experiments.

I must next say a few words upon the angry chidings of our little creatures; for their *anger* sometimes vents itself in sounds. I have often been amused with hearing the indignant tones of a humble-bee while lying upon its back. When I held my finger to it, it kicked and scolded with all its might. Hive-bees when irritated emit a shrill and peevish sound, continuing even when they are held under water, which John Hunter says vibrates at the point of contact with the air-holes at the root of their wings[c]. This sound is particularly sharp and angry when they fly at an intruder. The same sounds, or very similar ones, tell us when a wasp is offended, and we may expect to be stung;—but this passion of anger in insects is so nearly connected with their fear, that I need not enlarge further upon it.

Concerning their shouts of *joy* and cries of *sorrow* I have little to record: that pleasure or pain makes a difference in the tones of vocal insects is not improbable; but our auditory organs are not fine enough to catch all their different modulations. When Schirach had once smoked a hive to oblige the bees to retire to the top of it, the queen with some of the rest flew away. Upon this, those that remained in the hive sent forth a most plaintive

[a] Reaum. ii. 290—. [b] *Nouv. Obs.* ii. 300, note *.
[c] In *Philos. Trans.* 1792.

sound, as if they were all deploring their loss; when their sovereign was restored to them, these lugubrious sounds were succeeded by an agreeable humming, which announced their joy at the event[a]. Huber relates, that once when all the worker-brood was removed from a hive, and only male brood left, the bees appeared in a state of extreme despondency. Assembled in clusters upon the combs, they lost all their activity. The queen dropped her eggs at random; and instead of the usual active hum, a dead silence reigned in the hive[b].

But *love* is the soul of song with those that may be esteemed the most musical insects, the grasshopper tribes (*Gryllidæ*), and the long celebrated Cicada (*Tettigonia*, F.). You would suppose, perhaps, that the ladies would bear their share in these amatory strains. But here you would be mistaken—female insects are too intent upon their business, too coy and reserved to tell their love even to the winds.—The males alone

"Formosam resonare docent Amaryllida sylvas."

With respect to the *Cicadæ*, this was observed by Aristotle; and Pliny, as usual, has retailed it after him[c]. The observation also holds good with respect to the *Gryllidæ* and other insects, probably, whose love is musical. Olivier however has noticed an exception to this doctrine; for he relates, that in a species of beetle (*Pimelia striata*, F.), the female has a round granulated spot in the middle of the second segment of the abdomen, by striking which against any hard substance, she produces

[a] Schirach, 73— [b] i. 226—.
[c] Aristot. *Hist. Anim.* l. v. c. 30. Plin. *Hist. Nat.* l. xi. c. 26.

a rather loud sound, and that the male, obedient to this call, soon attends her, and they pair[a].

As I have nothing to communicate to you with respect to the love-songs of other insects, my further observations will be confined to the two tribes lately mentioned, the *Gryllidæ* and the *Cicadæ*.

No sound is to me more agreeable than the chirping of most of the Gryllidæ; it gives life to solitude, and always conveys to my mind the idea of a perfectly happy being. As these creatures are now very properly divided into several genera, I shall say a few words upon the song of such as are known to be vocal, separately.

The remarkable genus *Pneumora*—whose pellucid abdomen is blown up like a bladder, on which account they are called *Blaazops* by the Dutch colonists at the Cape —in the evening, for they are silent in the day, make a tremulous and tolerably loud noise, which is sometimes heard on every side[b]. The species of this genus have a much greater claim to the name of *Fiddlers*, than the insect lately mentioned, since their sound is produced by passing the hind-legs over a number of short transverse elevated ridges on the abdomen, which may be called their *fiddle-strings*[c].

The *cricket* tribe are a very noisy race, and their chirping is caused by the friction of the bases of their elytra against each other. For this purpose there is something peculiar in their structure, which I shall describe to you. The elytra of both sexes are divided longitudinally into two portions; a vertical or lateral one, which covers the sides; and a horizontal or dorsal one, which covers the

[a] Oliv. *Entomol.* i. Pref. ix. [b] Sparrman, *Voy.* i. 312.
[c] Plate XXIX. Fig. 13.

back. In the female both these portions resemble each other in their nervures; which running obliquely in two directions, by their intersection form numerous small lozenge-shaped or rhomboidal meshes or areolets. The elytra also of these have no elevation at their base. In the males the vertical portion does not materially differ from that of the females; but in the horizontal the base of each elytrum is elevated so as to form a cavity underneath. The nervures also, which are stronger and more prominent, run here and there very irregularly with various inflexions, describing curves, spirals, and other figures difficult and tedious to describe, and producing a variety of areolets of different size and shape, but generally larger than those of the female: particularly towards the extremity of the wing you may observe a space nearly circular, surrounded by one nervure, and divided into two areolets by another[a]. The friction of the nervures of the upper or convex surface of the base of the left-hand elytrum—which is the undermost—against those of the lower or concave surface of the base of the right-hand—which is the uppermost one—will communicate vibrations to the areas of membrane, more or less intense in proportion to the rapidity of the friction, and thus produce the sound for which these creatures are noted.

The merry inhabitant of our dwellings, the house-cricket (*Acheta domestica*, F.), though it is often heard by day, is most noisy in the night. As soon as it grows dusk, their shrill note increases till it becomes quite an annoyance, and interrupts conversation. When the male sings, he elevates the elytra so as to form an acute

[a] Compare De Geer, iii. 512.

angle with the body, and then rubs them against each other by a horizontal and very brisk motion[a]. The learned Scaliger is said to have been particularly delighted with the chirping of these animals, and was accustomed to keep them in a box for his amusement. We are told that they have been sold in Africa at a high price, and employed to procure sleep[b]. If they could be used to supply the place of laudanum, and lull the restlessness of busy thought in this country, the exchange would be beneficial. Like many other noisy persons, crickets like to hear nobody louder than themselves. Ledelius relates that a woman, who had tried in vain every method she could think of to banish them from her house, at last got rid of them by the noise made by drums and trumpets, which she had procured to entertain her guests at a wedding. They instantly forsook the house, and she heard of them no more[c].

The field-cricket (*Acheta campestris*, F.) makes a shrilling noise—still more sonorous than that of the house-cricket—which may be heard at a great distance. Mouffet tells us, that their sound may be imitated by rubbing their elytra, after they are taken off, against each other[d]. "Sounds," says Mr. White, "do not always give us pleasure according to their sweetness and melody; nor do harsh sounds always displease.—Thus the shrilling of the field-cricket, though sharp and stridulous, yet marvellously delights some hearers, filling their minds with a train of summer ideas of every

[a] De Geer, iii. 517. See also White, *Nat. Hist.* ii. 76;—and Rai. *Hist. Ins.* 63.
[b] Mouffet, 136.
[c] Goldsmith's *Animat. Nat.* vi. 28.
[d] *Ins. Theatr.* 134.

thing that is rural, verdurous, and joyous." One of these crickets, when confined in a paper cage and set in the sun, and supplied with plants moistened with water —for if they are not wetted it will die—will feed, and thrive, and become so merry and loud, as to be irksome in the same room where a person is sitting[a].

Having never seen a female of that extraordinary animal the mole-cricket (*Gryllotalpa vulgaris*, Latr.), I cannot say what difference obtains in the reticulation of the elytra of the two sexes. The male varies in this respect from the other male crickets, for they have no circular area, nor do the nervures run so irregularly; the areolets, however, toward their base are large, with very tense membrane. The base itself also is scarcely at all elevated. Circumstances these, which demonstrate the propriety of considering them distinct from the other crickets. This creature is not however mute. Where they abound they may be heard about the middle of April singing their love-ditty in a low, dull, jarring, uninterrupted note, not unlike that of the goat-sucker (*Caprimulgus europæus*, L.), but more inward[b]. I remember once tracing one by its shrilling to the very hole, under a stone, in the bank of my canal, in which it was concealed.

Another tribe of grasshoppers (*Locusta*, F.)—the females of which are distinguished by their long ensiform ovipositor—like the crickets, make their noise by the friction of the base of their elytra. And the chirping they thus produce is long, and seldom interrupted, which distinguishes it from that of the common grasshoppers (*Gryllus*, F.). What is remarkable, the grasshopper

[a] *Nat. Hist.* ii. 73. [b] Ibid. 81.

lark (*Sylvia locustella*), which preys upon them, makes a similar noise. Professor Lichtenstein in the *Linnean Transactions* has called the attention of naturalists to the eye-like area in the right wing of the males of this genus[a]; but he seems not to have been aware that De Geer had noticed it before him as a sexual character; who also, with good reason, supposes it to assist these animals in the sounds they produce. Speaking of *Locusta viridissima*—common with us—he says, "In our male grasshoppers, in that part of the right elytrum which is folded horizontally over the trunk, there is a round plate made of very fine transparent membrane, resembling a little mirror or piece of talc, of the tension of a drum. This membrane is surrounded by a strong and prominent nervure, and is concealed under the fold of the left elytrum, which has also several prominent nervures answering to the margin of the membrane or ocellus. There is," he further remarks, "every reason to believe that the brisk movement with which the grasshopper rubs these nervures against each other, produces a vibration in the membrane augmenting the sound. The males in question sing continually in the hedges and trees during the months of July and August, especially towards sun-set and part of the night. When any one approaches they immediately cease their song[b]."

The last description of singers that I shall notice amongst the Gryllidæ, are those that are more commonly denominated grasshoppers (*Gryllus*, F.). To this genus belong the little chirpers that we hear in every sunny bank, and which make vocal every heath.

[a] *Linn. Trans.* iv. 51— [b] De Geer, iii. 429.

They begin their song—which is a short chirp regularly interrupted, in which it differs from that of the *Locusta* —long before sun-rise. In the heat of the day it is intermitted, and resumed in the evening. This sound is thus produced:—Applying its posterior shank to the thigh, the animal rubs it briskly against the elytrum[a], doing this alternately with the right and left legs, which causes the regular breaks in the sound. But this is not their whole apparatus of song—since, like the Tettigoniæ, they have also a tympanum or drum." De Geer, who examined the insects he describes with the eye of an anatomist, seems to be the only entomologist that has noticed this organ. "On each side of the first segment of the abdomen," says he, "immediately above the origin of the posterior thighs, there is a considerable and deep aperture of rather an oval form, which is partly closed by an irregular flat plate or operculum of a hard substance, but covered by a wrinkled flexible membrane. The opening left by this operculum is semi-lunar, and at the bottom of the cavity is a white pellicle of considerable tension, and shining like a little mirror. On that side of the aperture which is towards the head, there is a little oval hole, into which the point of a pin may be introduced without resistance. When the pellicle is removed, a large cavity appears. In my opinion this aperture, cavity, and above all the membrane in tension, contribute much to produce and augment the sound emitted by the grasshopper[b]." This description, which was taken from the migratory locust (*G. migratorius*, L.), answers tolerably

[a] De Geer, iii. 470. [b] Ibid. 471. *t.* xxiii. *f.* 2. 3.

well to the tympanum of our common grasshoppers, only in them the aperture seems to be rather semicircular, and the wrinkled plate—which has no marginal hairs—is clearly a continuation of the substance of the segment. This apparatus so much resembles the drum of the Cicadæ, that there can be little doubt as to its use. The vibrations caused by the friction of the thighs and elytra striking upon this drum, are reverberated by it, and so intenseness is given to the sound. In Spain, we are told that people of fashion keep these animals—called there *Grillo*—in cages, which they name *Grilleria*, for the sake of their song [a].

I shall conclude this diatribe upon the noises of insects, with a tribe that have long been celebrated for their musical powers: I mean the *Cicadæ*, including the two genera *Fulgora*, L. and *Tettigonia*, F. The *Fulgoræ* appear to be night-singers, while the *Cicadæ* sing usually in the day. The great lantern-fly (*Fulgora laternaria*, L.), from its noise in the evening—nearly resembling the sound of a cymbal, or razor-grinder when at work—is called *Scare-sleep* by the Dutch in Guiana. It begins regularly at sun-set [b]. Perhaps an insect mentioned by Ligon as making a great noise in the night in Barbadoes, may belong to this tribe. "There is a kind of animal in the woods," says he, "that I never saw, which lie all day in holes and hollow trees, and as soon as the sun is down begin their tunes, which are neither singing nor crying, but the shrillest voices I ever heard: nothing can be so nearly resembled to it as the mouths of a pack of small

[a] Osbeck's *Voy.* i. 71. [b] Stedman's *Surinam*, ii. 37.

beagles at a distance; and so lively and chirping the noise is, as nothing can be more delightful to the ears, if there were not too much of it; for the music hath no intermission till morning, and then all is husht[a]."

The species of the other genus, *Tettigonia*, F., called by the ancient Greeks—by whom they were often kept in cages for the sake of their song—*Tettix*, seem to have been the favourites of every Grecian bard from Homer and Hesiod to Anacreon and Theocritus. Supposed to be perfectly harmless, and to live only upon the dew, they were addressed by the most endearing epithets, and were regarded as all but divine. One bard entreats the shepherds to spare the innoxious Tettix, that nightingale of the Nymphs, and to make those mischievous birds the thrush and blackbird their prey. Sweet prophet of the summer, says Anacreon, addressing this insect, the Muses love thee, Phœbus himself loves thee, and has given thee a shrill song; old age does not wear thee; thou art wise, earth-born, musical, impassive, without blood; thou art almost like a god[b]. So attached were the Athenians to these insects, that they were accustomed to fasten golden images of them in their hair, implying at the same time a boast that they themselves, as well as the Cicadæ, were *Terræ filii*. They were regarded indeed by all as the happiest as well as the most innocent of animals—not, we will suppose, for the reason given by the saucy Rhodian Xenarchus, when he says,

> "Happy the Cicadas' lives,
> Since they all have voiceless wives."

If the Grecian *Tettix* or *Cicada* had been distinguished

[a] *Hist. of Barbadoes*, 65. [b] *Epigramm. Delect.* 45. 234.

by a harsh and deafening note, like those of some other countries, it would hardly have been an object of such affection. That it was not, is clearly proved by the connexion which was supposed to exist between it and music. Thus the sound of this insect and of the harp were called by one and the same name[a]. A Cicada sitting upon a harp was a usual emblem of the science of music, which was thus accounted for:—When two rival musicians, Eunomus and Ariston, were contending upon that instrument, a Cicada flying to the former and sitting upon his harp, supplied the place of a broken string, and so secured to him the victory[b]. To excel this animal in singing seems to have been the highest commendation of a singer; and even the eloquence of Plato was not thought to suffer by a comparison with it[c]. At Surinam the noise of the *Tettigonia Tibicen* is still supposed so much to resemble the sound of a harp or lyre, that they are called there harpers (*Lierman*)[d]. Whether the Grecian Cicadæ maintain at present their ancient character for music, travellers do not tell us.

Those of other countries, however, have been held in less estimation for their powers of song; or rather have been execrated for the deafening din that they produce. Virgil accuses those of Italy of bursting the very shrubs with their noise[e]; and Dr. Smith observes that this species, which is very common, makes a most disagreeable dull chirping[f]. Another, *Tettigonia septendecim*—which fortunately, as its name imports, appears

[a] Gr. *τερετισμα.*

[b] Mouffet, *Theatr.* 130.

[c] Ἡδυεπυς Πλατων, και τεττιξιν ισολαλος.

[d] Merian *Surinam.* 49.

[e] Et cantu querulæ rumpent arbusta cicadæ. *Georg.* iii. 328.

[f] Smith's *Tour*, iii. 95.

only once in seventeen years—makes such a continual din from morning to evening that people cannot hear each other speak. They appear in Pennsylvania in incredible numbers in the middle of May[a].—"In the hotter months of summer," says Dr. Shaw, "especially from midday to the middle of the afternoon, the Cicada, τεττιξ, or grasshopper, as we falsely translate it, is perpetually stunning our ears with its most excessively shrill and ungrateful noise. It is in this respect the most troublesome and impertinent of insects, perching upon a twig and squalling sometimes two or three hours without ceasing; thereby too often disturbing the studies, or short repose that is frequently indulged, in these hot climates, at those hours. The τεττιξ of the Grèeks must have had a quite different voice, more soft surely and melodious; otherwise the fine orators of Homer, who are compared to it, can be looked upon no better than loud loquacious scolds[b]."—An insect of this tribe, and I am told a very noisy one, has been found by Mr. Daniel Bydder, before mentioned, in the New Forest, Hampshire. Previously to this it was not thought that any of these insect musicians were natives of the British Isles.—Captain Hancock informs me that the Brazilian Cicadæ sing so loud as to be heard at the distance of a mile. This is as if a man of ordinary stature, supposing his powers of voice increased in the ratio of his size, could be heard all over the world. So that Stentor himself becomes a mute when compared with these insects.

You feel very curious, doubtless, to know by what means these little animals are enabled to emit such pro-

[a] Collinson in *Philos. Trans.* 1763. Stoll, *Cigales*, 26.
[b] *Travels*, 2d Ed. 186.

digious sounds. I have lately mentioned to you the drum of certain grasshoppers; this, however, appears to be an organ of a very simple structure; but since it is essential to the economy of the Cicadæ that their males should so much exceed all other insects in the loudness of their tones, they are furnished with a much more complex, and indeed most wonderful, apparatus, which I shall now describe. If you look at the under-side of the body of a male, the first thing that will strike you is a pair of large plates of an irregular form—in some semi-oval, in others triangular, in others again a segment of a circle of greater or less diameter—covering the anterior part of the belly, and fixed to the trunk between the abdomen and the hind legs[a]. These are the drum-covers or opercula, from beneath which the sound issues. At the base of the posterior legs, just above each operculum, there is a small pointed triangular process (*pessellum*)[b], the object of which, as Reaumur supposes, is to prevent them from being too much elevated. When an operculum is removed, beneath it you will find on the exterior side a hollow cavity, with a mouth somewhat linear, which seems to open into the interior of the abdomen[c]: next to this, on the inner side, is another large cavity of an irregular shape, the bottom of which is divided into three portions; of these the posterior is lined obliquely with a beautiful membrane, which is very tense—in some species semi-opake, and in others transparent—and reflects all the colours of the rainbow. This mirror is not the real organ of sound,

[a] Plate VIII. Fig. 1. 8. a a. Reaum. v. *t.* xvi. *f.* 5. u u.
[b] Plate VIII. Fig. 18. b b. Reaum. *ubi supra, t.* xvi. *f.* 11. *b.*
[c] Reaum. ibid. *f.* 3. *l l.*

but is supposed to modulate it[a]. The middle portion is occupied by a plate of a horny substance, placed horizontally and forming the bottom of the cavity. On its inner side this plate terminates in a carina or elevated ridge, common to both drums[b]. Between the plate and the after-breast (*postpectus*) another membrane, folded transversely, fills an oblique, oblong, or semi-lunar cavity[c]. In some species I have seen this membrane in tension—probably the insect can stretch or relax it at its pleasure. But even all this apparatus is insufficient to produce the sound of these animals;—one still more important and curious yet remains to be described. This organ can only be discovered by dissection. A portion of the first and second segments being removed from that side of the back of the abdomen which answers to the drums, two bundles of muscles meeting each other in an acute angle, attached to a place opposite to the point of the mucro of the first ventral segment of the abdomen, will appear[d]. In Reaumur's specimens these bundles of muscles seem to have been cylindrical; but in one I dissected (*Tettigonia capensis*) they were tubiform, the end to which the true drum is attached being dilated[e]. These bundles consist of a prodigious number of muscular fibres applied to each other, but easily separable. Whilst Reaumur was examining one of these, pulling it from its place with a pin, he let it go again, and immediately, though the animal had been long dead, the usual sound was emitted. On each side of the drum-cavities, when the opercula are removed, another cavity of a lunulate shape, opening into the interior of the ab-

[a] Reaum. *ubi supra*, *f.* 3. m m. [b] Ibid. *q. q. c.* [c] Ibid. *n n.*
[d] Ibid. *f.* 6. *ff.* [e] Ibid. *f.* 9. *ff.* PLATE VIII. FIG. 19. b b.

domen, is observable[a]. In this is the true drum, the principal organ of sound, and its aperture is to the Cicada what our larynx is to us. If these creatures are unable themselves to modulate their sounds, here are parts enough to do it for them: for the mirrors, the membranes, and the central portions, with their cavities, all assist in it. In the cavity last described, if you remove the lateral part of the first dorsal segment of the abdomen, you will discover a semi-opaque and nearly semicircular concavo-convex membrane with transverse folds—this is the drum[b]. Each bundle of muscles, before mentioned, is terminated by a tendinous plate nearly circular, from which issue several little tendons that, forming a thread, pass through an aperture in the horny piece that supports the drum, and are attached to its under or concave surface. Thus the bundle of muscles being alternately and briskly relaxed and contracted, will by its play draw in and let out the drum: so that its convex surface being thus rendered concave when pulled in, when let out a sound will be produced by the effort to recover its convexity; which, striking upon the mirror and other membranes before it escapes from under the operculum, will be modulated and augmented by them[c]. I should imagine that the muscular bundles are extended and contracted by the alternate approach

[a] Reaum. *ubi supr. f.* 3. *l l.* [b] Ibid. *f.* 6. *t t. f.* 9.

[c] PLATE VIII. FIG. 19. c c. The figure given in this plate does not show the drums clearly; but the principal object of it was to exhibit the bundles of muscles, which are of a different form from those in Reaumur's figures. In the above figure, a. is the *mirror;* bb. the *bunches of muscles;* cc. the *drums;* d. the *back* of the *abdomen;* e. the *belly*.

and recession of the trunk and abdomen to and from each other.

And now, my friend, what adorable wisdom, what consummate art and skill are displayed in the admirable contrivance and complex structure of this wonderful, this unparalleled apparatus! The GREAT CREATOR has placed in these insects an organ for producing and emitting sounds, which in the intricacy of its construction seems to resemble that which he has given to man, and the larger animals, for receiving them. Here is a *cochlea;* a *meatus;* and, as it should seem, more than one *tympanum.*

I am, &c.

LETTER XXV.

ON LUMINOUS INSECTS.

WE boast of our candles, our wax-lights, and our Argand lamps, and pity our fellow-men who, ignorant of our methods of producing artificial light, are condemned to pass their nights in darkness. We regard these inventions as the results of a great exertion of human intellect, and never conceive it possible that other animals are able to avail themselves of modes of illumination equally efficient; and are furnished with the means of guiding their nocturnal evolutions by actual lights, similar in their effect to those which we make use of. Yet many insects are thus provided. Some are forced to content themselves with a single candle, not more vivid than the rush-light which glimmers in the peasant's cottage; others exhibit two or four, which cast a stronger radiance; and a few can display a lamp little inferior in brilliancy to some of ours. Not that these insects are actually possessed of candles and lamps. You are aware that I am speaking figuratively. But Providence has supplied them with an effectual substitute—a luminous preparation or secretion, which has all the advantages of our lamps and candles without their inconveniences; which gives light sufficient to direct

their motions, while it is incapable of burning; and whose lustre is maintained without needing fresh supplies of oil or the application of the snuffers.

Of the insects thus singularly provided, the common glow-worm (*Lampyris noctiluca*) is the most familiar instance. Who that has ever enjoyed the luxury of a summer evening's walk in the country, in the southern parts of our island, but has viewed with admiration these "stars of the earth and diamonds of the night?" And if, living like me in a district where it is rarely met with, the first time you saw this insect, chanced to be, as it was in my case, one of those delightful evenings which an English summer seldom yields, when not a breeze disturbs the balmy air, and "every sense is joy," and hundreds of these radiant worms, studding their mossy couch with mild effulgence, were presented to your wondering eye in the course of a quarter of a mile,—you could not help associating with the name of glow-worm the most pleasing recollections. No wonder that an insect, which chiefly exhibits itself on occasions so interesting, and whose economy is so remarkable, should have afforded exquisite images and illustrations to those poets who have cultivated Natural History.

If you take one of these glow-worms home with you for examination, you will find that in shape it somewhat resembles a caterpillar, only that it is much more depressed; and you will observe that the light proceeds from a pale-coloured patch that terminates the underside of the abdomen. It is not, however, the larva of an insect, but the perfect female of a winged beetle, from which it is altogether so different, that nothing but actual observation could have inferred the fact of their

being the sexes of the same insect. In the course of our inquiries you will find that sexual differences even more extraordinary exist in the insect world.

It has been supposed by many that the males of the different species of *Lampyris* do not possess the property of giving out any light; but it is now ascertained that this supposition is inaccurate, though their light is much less vivid than that of the female. Ray first pointed out this fact with respect to *L. noctiluca*[a]. Geoffroy also observed that the male of this species has four small luminous points, two on each of the two last segments of the belly[b]: and his observation has been recently confirmed by Müller. This last entomologist, indeed, saw only two shining spots; but from the insect's having the power of withdrawing them out of sight so that not the smallest trace of light remains, he thinks it is not improbable that at times two other points still smaller may be exhibited, as Geoffroy has described. In the males of *L. Splendidula* and of *L. hemiptera* the light is very distinct, and may be seen in the former while flying[c].—The females have the same faculty of extinguishing or concealing their light—a very necessary provision to guard them from the attacks of nocturnal birds: Mr. White even thinks that they regularly put it out between eleven and twelve every night[d]: and they have also the power of rendering it for a while more vivid than ordinary.

Authors who have noticed the luminous parts of the common female glow-worm, having usually contented themselves with stating that the light issues from the

[a] *Hist. Ins.* 81. [b] *Hist. abreg.* i. 168. [c] Illiger *Mag.* iv. 195.
[d] *Nat. Hist.* ii. 279.

three last ventral segments of the abdomen[a]; I shall give you the result of some observations I once made upon this subject. One evening, in the beginning of July, meeting with two of these insects, I placed them on my hand. At first their light was exceedingly brilliant, so as to appear even at the junctions of the upper or dorsal segments of the abdomen. Soon after I had taken them, one withdrew its light altogether, but the other continued to shine. While it did this it was laid upon its back, the abdomen forming an angle with the rest of its body, and the last or anal segment being kept in constant motion. This segment was distinguished by two round and very vivid spots of light; which, in the specimen that had ceased to shine, were the last that disappeared, and they seem to be the first parts that become luminous when the animal is disposed to yield its light. The penultimate and antepenultimate segments each exhibited a middle transverse band of yellow radiance, terminated towards the trunk by an obtusely-dentated line; a greener and fainter light being emitted by the rest of the segment.

Though many of the females of the different species of *Lampyris* are without wings and even elytra, (in which circumstance they differ from all other apterous *Coleoptera*,) this is not the case with all. The female of *L. italica*, a species common in Italy, and which, if we may trust to the accuracy of the account given by Mr. Waller in the *Philosophical Transactions* for 1684, would seem to have been taken by him in Hertfordshire, is winged: and when a number of these moving stars are seen to dart through the air in a dark night, nothing can

[a] Geoffr. i. 167. De Geer, iv. 35.

have a more beautiful effect. Dr. Smith tells us that the beaus of Italy are accustomed in an evening to adorn the heads of the ladies with these artificial diamonds by sticking them into their hair; and a similar custom, as I have before informed you[a], prevails amongst the ladies of India.

Besides the different species of the genus *Lampyris*, all of which are probably more or less luminous, another insect of the beetle tribe, *Elater noctilucus*, is endowed with the same property, and that in a much higher degree. This insect, which is an inch long, and about one-third of an inch broad, gives out its principal light from two transparent eye-like tubercles placed upon the thorax; but there are also two luminous patches concealed under the elytra, which are not visible except when the insect is flying, at which time it appears adorned with four brilliant gems of the most beautiful golden-blue lustre: in fact, the whole body is full of light, which shines out between the abdominal segments when stretched. The light emitted by the two thoracic tubercles alone is so considerable, that the smallest print may be read by moving one of these insects along the lines; and in the West India islands, particularly in St. Domingo, where they are very common, the natives were formerly accustomed to employ these living lamps, which they called *Cucuij*, instead of candles in performing their evening household occupations. In travelling at night they used to tie one to each great toe; and in fishing and hunting required no other flambeau[b].—Southey has happily introduced this insect in his "*Madoc*" as furnishing the lamp

[a] Vol. I. 4th Ed. 314.

[b] Pietro Martire, *The Decades of the New Word*, quoted in *Madoc*, p. 543.

by which Coatel rescued the British hero from the hands of the Mexican priests.

> "She beckon'd and descended, and drew out
> From underneath her vest a cage, or net
> It rather might be call'd, so fine the twigs
> Which knit it, where, confined, two Fire-flies gave
> Their lustre. By that light did Madoc first
> Behold the features of his lovely guide."

Pietro Martire tells us that the Cucuij serve the natives of the Spanish West India islands not only instead of candles, but as extirpators of the gnats, which are a dreadful pest to the inhabitants of the low grounds. They introduce a few fire-flies, to which the gnats are a grateful food, into their houses, and by means of these "commodious hunters" are soon rid of the intruders. "How they are a remedy," says this author, "for so great a mischiefe it is a pleasant thing to hear. Hee who understandeth he hath those troublesome guestes (the gnattes) at home, diligently hunteth after the Cucuij. Whoso wanteth Cucuij goeth out of the house in the first twilight of the night, carrying a burning fire-brande in his hande, and ascendeth the next hillock that the Cucuij may see it, and hee swingeth the fire-brande about, calling Cucuius aloud, and beating the ayre with often calling out *Cucuie, Cucuie*." He goes on to observe, that the simple people believe the insect is attracted by their invitations; but that, for his part he is rather inclined to think that the fire is the magnet. Having obtained a sufficient number of Cucuij, the beetle-hunter returns home and lets them fly loose in the house, where they diligently seek the gnats about the beds and the faces of those asleep, and devour them [a].—These insects are also

[a] P. Martire, *ubi supr.*

applied to purposes of decoration. On certain festival days, in the month of June, they are collected in great numbers, and tied all over the garments of the young people, who gallop through the streets on horses similarly ornamented, producing on a dark evening the effect of a large moving body of light. On such occasions the lover displays his gallantry by decking his mistress with these living gems[a]. And according to P. Martire, "many wanton wilde fellowes" rub their faces with the flesh of a killed Cucuius, as boys with us use phosphorus, "with purpose to meet their neighbours with a flaming countenance," and derive amusement from their fright.

Besides *Elater noctilucus*, *E. ignitus* and several others of the same genus are luminous. Not fewer than twelve species of this family are described by Illiger in the *Berlin Naturalist Society's Magazine*[b].

The brilliant nocturnal spectacle presented by these insects to the inhabitants of the countries where they abound cannot be better described than in the language of the poet above referred to, who has thus related its first effect upon the British visitors of the new world:

"....................Sorrowing we beheld
The night come on; but soon did night display
More wonders than it veil'd: innumerous tribes
From the wood-cover swarm'd, and darkness made
Their beauties visible: one while they stream'd
A bright blue radiance upon flowers that closed
Their gorgeous colours from the eye of day;
Now motionless and dark, eluded search,
Self-shrouded; and anon, starring the sky,
Rose like a shower of fire."

[a] Walton's *Present State of the Spanish Colonies*, i. 128.
[b] *Iahrgang*, i. 141.

The beautiful poetical imagery with which Mr. Southey has decorated this and a few other entomological facts, will make you join in my regret that a more extensive acquaintance with the science has not enabled him to spread his embellishments over a greater number. The gratification which the entomologist derives from seeing his favourite study adorned with the graces of poetry is seldom unalloyed with pain, arising from the inaccurate knowledge of the subject in the poet. Dr. Darwin's description of the beetle to which the nut-maggot is transformed may delight him (at least if he be an admirer of the Darwinian style) as he reads for the first time,

> "So sleeps in silence the Curculio, shut
> In the dark chamber of the cavern'd nut;
> Erodes with ivory beak the vaulted shell,
> And quits on filmy wings its narrow cell."

But when the music of the lines has allowed him room for pause, and he recollects that they are built wholly upon an incorrect supposition, the Curculio never inhabiting the nut in its beetle shape, nor employing its ivory or rather ebony beak upon it, but undergoing its transformation under ground, he feels disappointed that the passage has not truth as well as sound.—Mr. Southey, too, has fallen into an error: he confounds the fire-fly of St. Domingo (*Elater noctilucus*) with a quite different insect, the lantern-fly (*Fulgora laternaria*) of Madam Merian; but happily this error does not affect his poetry.

But to return from this digression.—If we are to believe Mouffet, (and the story is not incredible,) the appearance of the tropical fire-flies one occasion led to a

more important result than might have been expected from such a cause. He tells us, that when Sir Thomas Cavendish and Sir Robert Dudley first landed in the West Indies, and saw in the evening an infinite number of moving lights in the woods, which were merely these insects, they supposed that the Spaniards were advancing upon them, and immediately betook themselves to their ships[a] :—a result as well entitling the Elaters to a commemoration feast, as a similar good office the land-crabs of Hispaniola, which, as the Spaniards tell, (and the story is confirmed by an anniversary *Fiesta de lôs Cangrejos,*) by their clattering—mistaken by the enemy for the sound of Spanish cavalry close upon their heels—in like manner scared away a body of English invaders of the city of St. Domingo[b].

An anecdote less improbable, perhaps, and certainly more ludicrous, is related by Sir James Smith of the effect of the first sight of the Italian fire-flies upon some Moorish ladies ignorant of such appearances. These females had been taken prisoners at sea, and, until they could be ransomed, lived in a house in the outskirts of Genoa, where they were frequently visited by the respectable inhabitants of the city; a party of whom, on going one evening, were surprised to find the house closely shut up, and their Moorish friends in the greatest grief and consternation. On inquiring into the cause, they ascertained that some of the *Lampyris italica* had found their way into the dwelling, and that the ladies within had taken it into their heads that these brilliant guests were no other than the troubled spirits of their

[a] 112. [b] Walton's *Hispaniola*, i. 39.

relations; of which idea it was some time before they could be divested.—The common people in Italy have a superstition respecting these insects somewhat similar, believing that they are of a spiritual nature, and proceed out of the graves, and hence carefully avoid them[a].

The insects hitherto adverted to have been beetles, or of the order *Coleoptera*. But besides these, a genus in the order *Hemiptera*, called *Fulgora*, includes several species which emit so powerful a light as to have obtained in English the generic appellation of *Lantern-flies*. Two of the most conspicuous of this tribe are the *F. laternaria* and *F. candelaria*; the former a native of South America, the latter of China. Both, as indeed is the case with the whole genus, have the material which diffuses their light included in a hollow subtransparent projection of the head. In *F. candelaria* this projection is of a subcylindrical shape, recurved at the apex, above an inch in length, and the thickness of a small quill. We may easily conceive, as travellers assure us, that a tree studded with multitudes of these living sparks, some at rest and others in motion, must at night have a superlatively splendid appearance.—In *F. laternaria*, which is an insect two or three inches long, the snout is much larger and broader, and more of an oval shape, and sheds a light the brilliancy of which transcends that of any other luminous insect. Madam Merian informs us, that the first discovery which she made of this property caused her no small alarm. The Indians had brought her several of these insects, which by day-light exhibited no extraordinary

[a] *Tour on the Continent*, 2d Edit. iii. 85.

appearance, and she inclosed them in a box until she should have an opportunity of drawing them, placing it upon a table in her lodging-room. In the middle of the night the confined insects made such a noise as to awake her, and she opened the box, the inside of which to her great astonishment appeared all in a blaze; and in her fright letting it fall, she was not less surprised to see each of the insects apparently on fire. She soon, however, divined the cause of this unexpected phenomenon, and re-inclosed her brilliant guests in their place of confinement. She adds, that the light of one of these *Fulgoræ* is sufficiently bright to read a newspaper by: and though the tale of her having drawn one of these insects by its own light is without foundation, she doubtless might have done so if she had chosen[a].—Another species (*F. pyrrhorynchus*) is figured by Mr. Donovan in his *Insects of India*, of which the light, though from a smaller snout than that of *F. laternaria*, must assume a more splendid and striking appearance, the projection being of a rich deep purple from the base to near the apex, which is of

[a] *Ins. Sur.* 49.—The above account of the luminous properties of *Fulgora laternaria* is given, because negative evidence ought not hastily to be allowed to set aside facts positively asserted by an author whose veracity is unimpeached; but it is necessary to state, that not only have several of the inhabitants of Cayenne, according to the French *Dictionnaire d'Histoire Naturelle*, denied that this insect shines, in which denial they are joined by M. Richard, who reared the species (*Encyclopédie*, art. *Fulgora*); but the learned and accurate Count Hoffmansegg informs us, that his insect collector Sieber, a practised entomologist of thirty years standing, and who, when in the Brazils for some years, took many specimens, affirms that he never saw a single one in the least luminous. *Der Gesellschaft Naturf. Fr. zu Berlin Mag.* i. 153.

a fine transparent scarlet; and these tints will of course be imparted to the transmitted light.

In addition to the insects already mentioned, some others have the power of diffusing light, as two species of *Scolopendra* (*S. electrica* and *phosphorea*), and probably others of the same genus. In these the light is not confined to one part, but proceeds from the whole body. *S. electrica* is a common insect in this country, residing under clods of earth, and often visible at night in gardens. *S. phosphorea*, a native of Asia, is an obscure species, described by Linné, on the authority of C. G. Ekeberg, the captain of a Swedish East Indiaman, who asserted that it dropped from the air, shining like a glow-worm, upon his ship, when sailing in the Indian ocean a hundred miles (Swedish) from the continent. However singular this statement, it is not incredible. The insect may either, as Linné suspects, have been elevated into the atmosphere by wings with which, according to him, one species of the genus is provided; or more probably, perhaps, by a strong wind, such as that which raised into the air the shower of insects mentioned by De Geer as occurring in Sweden in the winter of 1749, after a violent storm that had torn up trees by the roots, and carried away to a great distance the surrounding earth, and insects which had taken up their winter quarters amongst it[a]. That

[a] De Geer, iv. 63.—These insects, which were chiefly *Staphylini*, L., small *Scarabæi*, L., spiders, caterpillars, but particularly the larvæ of *Cantharis fusca*, fell in such abundance that they might have been taken from the snow by handfuls.—Other showers of insects which have been recorded, as that in Hungary, 20th November 1672 (*Ephem. Nat. Curios.* 1673. 80.), and one mentioned in the news-

the wind may convey the light body of an insect to the above-mentioned distance from land, you will not dispute when you call to mind that our friend Hooker, in his interesting *Tour in Iceland*, tells us that the ashes from the eruption of one of the Icelandic volcanos in 1755 were conveyed to Ferrol, a distance of upwards of 300 miles[a].—Lastly, to conclude my list of luminous insects, Professor Afzelius observed "a dim phosphoric light" to be emitted from the singular hollow antennæ of *Pausus sphærocerus*[b]. A similar appearance has been noticed in the eyes of *Noctua Psi*, *Bombyx Cossus*, and other moths. *Chiroscelis bifenestrata* of Lamarck, a beetle, has two red oval spots covered with a downy membrane on the second segment of the abdomen, which he thinks indicate some particular organ perhaps luminous[c]: and M. Latreille informs me that a friend of his, who saw one living which was brought from China to the Isle of France in wood, found that the *ocelli* in the elytra of *Buprestis ocellata* were luminous.

But besides the insects here enumerated, others may be luminous which have not hitherto been suspected of being so. This seems proved by the following fact. A learned friend[d] has informed me, that when he was curate of Ickleton, Cambridgeshire, in 1780, a farmer of that place of the name of Simpringham brought to

papers of July 2d, 1810, to have fallen in France the January preceding, accompanied by a shower of red snow, may evidently be explained in the same manner.

[a] p. 407. [b] *Linn. Trans.* iv. 261. [c] Latr. *Hist. Nat.* x. 262.

[d] Rev. Dr. Sutton of Norwich.

him a mole-cricket (*Gryllotalpa vulgaris*, Latr.), and told him that one of his people, seeing a *Jack-o'lantern*, pursued it and knocked it down, when it proved to be this insect, and the identical specimen shown to him.

This singular fact, while it renders it probable that some insects are luminous which no one has imagined to be so, seems to afford a clue to the, at least, partial explanation of the very obscure subject of *ignes fatui*, and to show that there is considerable ground for the opinion long ago maintained by Ray and Willughby, that the majority of these supposed meteors are no other than luminous insects. That the large varying lambent flames, mentioned by Beccaria to be very common in some parts of Italy, and the luminous globe seen by Dr. Shaw[a] cannot be thus explained, is obvious. These were probably electrical phenomena: certainly not explosions of phosphuretted hydrogene, as has been suggested by some, which must necessarily have been momentary. But that the *ignis fatuus* mentioned by Derham as having been seen by himself, and which he describes as flitting about a thistle[b], was, though he seems of a different opinion, no other than some luminous insect, I have little doubt. Mr. Sheppard informs me that, travelling one night between Stamford and Grantham on the top of the stage, he observed for more than ten minutes a very large *ignis fatuus* in the low marshy grounds, which had every appearance of being an insect. The wind was very high: consequently, had it been a vapour, it must have been carried forward

[a] *Travels*, 2d Ed. 334. [b] *Phil. Trans.* 1729. 204.

in a direct line; but this was not the case. It had the same motions as a Tipula, flying upwards and downwards, backwards and forwards, sometimes appearing as settled, and sometimes as hovering in the air.—Whatever be the true nature of these meteors, of which so much is said and so little known, it is singular how few modern instances of their having been observed are on record. Dr. Darwin declares, that though in the course of a long life he had been out in the night, and in the places where they are said to appear, times without number, he had never seen any thing of the kind: and from the silence of other philosophers of our own times, it should seem that their experience is similar.

With regard to the immediate source of the luminous properties of these insects, Mr. Macartney, to whom we are indebted for the most recent investigation on the subject, has ascertained that in the common glow-worm, and in *Elater noctilucus* and *ignitus*, the light proceeds from masses of a substance not generally differing, except in its yellow colour, from the interstitial substance (*corps graisseux*) of the rest of the body, closely applied underneath those transparent parts of the insects' skin which afford the light. In the glow-worm, besides the last-mentioned substance, which, when the season for giving light is passed, is absorbed, and replaced by the common interstitial substance, he observed on the inner side of the last abdominal segment two minute oval sacs formed of an elastic spirally-wound fibre similar to that of the tracheæ, containing a soft yellow substance of a closer texture than that which lines the adjoining region, and affording a more permanent and brilliant light.

This light he found to be less under the control of the insect than that from the adjoining luminous substance, which it has the power of voluntarily extinguishing, not by retracting it under a membrane, as Carradori imagined, but by some inscrutable change dependent upon its will: and when the latter substance was extracted from living glow-worms it afforded no light, while the two sacs in like circumstances shone uninterruptedly for several hours. Mr. Macartney conceives, from the radiated structure of the interstitial substance surrounding the oval yellow masses immediately under the transparent spots in the thorax of *Elater noctilucus*, and the subtransparency of the adjoining crust, that the interstitial substance in this situation has also the property of shining—a supposition which, if De Geer and other authors be correct in stating that this insect has two luminous patches under its elytra, and that the incisures between the abdominal segments shine when stretched, may probably be extended to the *whole* of the interstitial substance of its body.—What peculiar organization contributes to the production of light in the hollow projections of *Fulgora laternaria* and *candelaria*, the hollow antennæ of *Pausus sphærocerus*, and under the whole integument of *Scolopendra electrica*, Mr. Macartney was unable to ascertain. Respecting this last he remarks, what I have myself observed, that there is an apparent effusion of a luminous fluid on its surface, that may be received upon the hand, which exhibits a phosphoric light for a few seconds afterwards; and that it will not shine unless it have been previously exposed for a short time to the solar light[a].

[a] *Phil. Trans.* 1810, p. 281.—Mr. Macartney's statement on this

With respect to the remote cause of the luminous property of insects, philosophers are considerably divided in opinion. The disciples of modern Chemistry have in general, with Dr. Darwin, referred it to the slow combustion of some combination of phosphorus secreted from their fluids by an appropriate organization, and entering into combination with the oxygene supplied in respiration. This opinion is very plausibly built upon the ascertained existence of phosphoric acid as an animal secretion; the great resemblance between the light of phosphorus in slow combustion and animal light; the remarkably large spiracula in glow-worms; and upon the statement, that the light of the glow-worm is rendered more brilliant by the application of heat and oxygene gas, and is extinguished by cold and by hydrogene and carbonic acid gases. From these last facts Spallanzani was led to regard the luminous matter as a compound of hydrogene and carburetted hydrogene gas. Carradori having found that the luminous portion of the belly of the Italian glow-worm (*Lampyris italica*) shone in vacuo, in oil, in water, and when under other circumstances where the presence of oxygene gas was precluded, with Brugnatelli ascribed the property in question to the imbibition of light separated from the food or air taken into the body, and afterwards secreted in a sensible form[a]. Lastly, Mr. Macartney having ascertained by experiment that the light of a glow-worm is not diminished by immersion in water, or increased by the ap-

point is not very clear. He probably means that the insect will not shine in a dark place in the *day time,* unless previously exposed to the solar light: for it is often seen to shine at night when it could have had no *recent* exposure to the sun.

[a] *Annal. di Chimica,* xiii. 1797. *Phil. Mag.* ii. 80.

plication of heat; that the substance affording it, though poetically employed for lighting the fairies' tapers[a], is incapable of inflammation if applied to the flame of a candle or red-hot iron; and when separated from the body exhibits no sensible heat on the thermometer's being applied to it—rejects the preceding hypotheses as unsatisfactory, but without substituting any other explanation; suggesting, however, that the facts he observed are more favourable to the supposition of light being a quality of matter than a substance[b].

Which of these opinions is the more correct I do not pretend to decide. But though the experiments of Mr. Macartney seem fairly to bear him out in denying the existence of any ordinary combination of phosphorus in luminous insects, there exists a contradiction in many of the statements, which requires reconciling before final decision can be pronounced. The different results obtained by Forster and Spallanzani, who assert that glow-

[a] "And for night-tapers crop their waxen thighs,
And light them at the fiery glow-worms' eyes."

[b] Some experiments made by my friend the Rev. R. Sheppard on the glow-worm are worthy of being recorded.—One of the receptacles being extracted with a penknife continued luminous; but on being immersed in camphorated spirit of wine became immediately extinct. The animal, with one of its receptacles uninjured, being plunged into the same spirit, became apparently lifeless in less than a minute; but the receptacle continued luminous for five minutes, the light gradually disappearing.—Having extracted the luminous matter from the receptacles, in two days they were healed, and filled with luminous matter as before. He found this matter to lose its luminous property, and become dry and glossy like gum, in about two minutes; but it recovered it again on being moistened with saliva, and again lost it when dried. When the matter was extracted from two or three glow-worms, and covered with liquid gum-arabic, it continued luminous for upwards of a quarter of an hour.

worms shine more brilliantly in oxygene gas, and by Beckerheim, Dr. Hulme, and Sir H. Davy, who could perceive no such effect, may perhaps be accounted for by the supposition that in the latter instances the insects having been taken more recently, might be less sensible to the stimulus of the gas than in the former, where possibly their irritability was, as Brown would say, accumulated by a longer abstinence: but it is not so easy to reconcile the experiment of Sir H. Davy, who found the light of the glow-worm not to be sensibly diminished in hydrogene gas[a], with those of Spallanzani and Dr. Hulme, who found it to be extinguished by the same gas, as well as by carbonic acid, nitrous and sulphuretted hydrogene gases[b]. Possibly some of these contradictory results were occasioned by not adverting to the faculty which the living insect possesses of extinguishing its lights at pleasure; or different philosophers may have experimented on different species of Lampyris.

The general use of this singular provision is not much more satisfactorily ascertained than its nature. I have before conjectured—and in an instance I then related it seemed to be so—that it may be a means of defence against their enemies[c]. In different kinds of insects, however, it may probably have a different object. Thus in the lantern-flies (*Fulgora*), whose light precedes them, it may act the part that their name imports, enabling them to discover their prey, and to steer themselves safely in the night. In the fire-flies (*Elater*), if we consider the infinite numbers that in certain climates and

[a] *Philos. Trans.* 1810, p. 287. [b] Ibid. 1801, p. 483.
[c] See above, p. 228.

situations present themselves every where in the night, it may distract the attention of their enemies or alarm them. And in the glow-worm—since their light is usually most brilliant in the female; in some species, if not all, present only in the season when the sexes are destined to meet; and strikingly more vivid at the very moment when the meeting takes place[a]—besides the above uses, it is most probably intended to conduct the sexes to each other. This seems evidently the design in view in those species in which, as in the common glow-worm (*L. noctiluca*, L.), the females are apterous. The torch which the wingless female, doomed to crawl upon the grass, lights up at the approach of night, is a beacon which unerringly guides the vagrant male to her "love-illumined form," however obscure the place of her abode. It has been objected, however, to this explanation, that—since both larva and pupa, as De Geer observed[b], and the males shine as well as the females—the meeting of the sexes can scarcely be the object of their luminous provision. But this difficulty appears to me easily surmounted. As the light proceeds from a peculiarly organized substance, which probably must in part be elaborated in the larva and pupa states, there seems nothing inconsistent in the fact of *some* light being then emitted with the supposition of its being destined solely for use in the perfect state: and the circumstance of the male having the same luminous property, no more proves that the superior brilliancy of the female is not intended for conducting him to her, than the existence of nipples and sometimes of milk in man proves that the breast of

[a] Müller in *Illig. Mag.* iv. 178. [b] iv. 49.

woman is not meant for the support of her offspring. We often see without being able to account for the fact, except on Sir E. Home's idea, that the sex of the ovum is undetermined[a], traces of an organization in one sex indisputably intended for the sole use of the other.

I am, &c.

[a] *Phil. Trans.* 1799. 157.

LETTER XXVI.

ON THE HYBERNATION AND TORPIDITY OF INSECTS.

IF insects can boast of enjoying a greater variety of food than many other tribes of animals, this advantage seems at first sight more than counterbalanced in our climates, by the temporary nature of their supply. The graminivorous quadrupeds, with few exceptions, however scanty their bill of fare, and their carnivorous brethren, as well as the whole race of birds and fishes, can at all seasons satisfy, in greater or less abundance, their demand for food. But to the great majority of insects, the earth for nearly one half of the year is a barren desert, affording no appropriate nutriment. As soon as winter has stripped the vegetable world of its foliage, the vast hosts of insects that feed on the leaves of plants must necessarily fast until the return of spring: and even the carnivorous tribes, such as the *Carabidæ*, *Ichneumonidæ*, *Sphegidæ*, &c. would at that period of the year in vain look for their accustomed prey.

How is this difficulty provided for? In what mode has the Universal Parent secured an uninterrupted succession of generations in a class of animals for the most

part doomed to a six months' deprivation of the food which they ordinarily devour with such voracity? By a beautiful series of provisions founded on the faculty, common also to some of the larger animals, of passing the winter in a state of torpor—by ordaining that the insect shall live through that period, either in an incomplete state of its existence when its organs of nutrition are undeveloped, or, if the active epoch of its life has commenced, that it shall seek out appropriate *hybernacula* or winter quarters, and in them fall into a profound sleep, during which a supply of food is equally unnecessary.

In two of the four states of existence common to insects, in which different tribes pass the winter, namely, the egg and the pupa state, the organs for taking food (except in some cases in the latter) are not developed, and consequently the animal is incapable of eating. The existence of insects in these states during the winter, differs from their existence in the same form in summer only in the greater length of its term. In both seasons food is alike unnecessary, so that their hybernation in these circumstances has little or nothing analogous to that of larger animals. With this, however, strictly accords their hybernation in the larva and imago states, in which their abstinence from food is solely owing to the torpor that pervades them, and the consequent non-expenditure of the vital powers.—I shall attend to the peculiarities of their hybernation in each of these states in the order just laid down; premising that we have yet much to learn on this subject, no observations having been instituted respecting the state in which multitudes of insects pass the winter.

It is probable that some insects of almost every order hybernate in the *egg* state: though that these must be comparatively few in number, seems proved from two considerations: first, That the majority of insects assume the imago, and deposit their eggs in the summer and early part of autumn, when the heat suffices to hatch them in a short period: and secondly, That the eggs of a very large proportion of insects require for their due exclusion and the nutriment of the larvæ springing from them, conditions only to be fulfilled in summer, as all those which are laid in young fruits and seeds; in the interior and galls of leaves; in insects that exist only in summer, &c. &c. The insects which pass the winter in the egg state are chiefly such as have several broods in the course of the year, the females of the last of which lay eggs that, requiring more heat for their development than then exists, necessarily remain dormant until the return of spring.

The situation in which the female insect places her eggs in order to their remaining there through the winter, is always admirably adapted to the degree of cold which they are capable of sustaining; and to the ensuring a due supply of food for the nascent larvæ. Thus, with the former view, *Gryllus verrucivorus* and many other insects whose eggs are of a tender consistence, deposit them deep in the earth out of the reach of frost; and with the latter, *Bombyx Neustria*, *B. castrensis*, *B. dispar*, and some other moths, departing from the ordinary instinct of their congeners, which teaches them to place their eggs upon the *leaves* of plants, fix theirs to the stem and branches only. That this variation of procedure has reference to the hybernation of the eggs of

these particular species, is abundantly obvious. Insects whose eggs are to be hatched in summer, usually fix them slightly to the leaves upon which the larvæ are to feed. But it is evident that, were this plan to be adopted by those whose eggs remain through the winter, their progeny might be blown away along with the leaf to which they are attached, far from their destined food. These, therefore, choose a more stable support, and carefully fasten them, as has just been observed, either to the trunk or branches of the tree, whose young leaves in spring are to be the food of the excluded larvæ. The latter plan is followed by the female of *Bombyx Neustria*, which curiously gums her eggs in bracelets round the twigs of the hawthorn, &c. But another provision is demanded. Were these eggs of the usual delicate consistence, and to be attached with the ordinary slight gluten, they would have a poor chance of surviving the storms of rain and snow and hail to which for six or eight months they are exposed. They are therefore covered with a shell much more hard and thick than common; packed as closely as possible to each other; and the interstices are filled up with a tenacious gum, which soon hardens the whole into a solid mass almost capable of resisting a penknife. Thus secured, they defy the elements and brave the blasts of winter uninjured.—The female of *Bombyx dispar*, whose eggs have a more tender shell, glues them in an oval mass to the stem of a tree (whence the German gardeners call the larvæ *Stamm-raupe*), and then covers them with a warm non-conducting coat of hairs plucked from her own body, equally impervious to cold and wet.

Another of those beautiful relations between objects at first sight apparently unconnected, which at every step

reward the votaries of entomology, is afforded by the coincidence between the period of the hatching in spring of eggs deposited before winter, and of the leafing of the trees upon which they have been fixed, and on whose foliage the larvæ are to feed: which two events, requiring exactly the same temperature, are always simultaneous. Of this fact I have had a striking exemplification the last spring (1816). On the 20th of February, observing the twigs of the birches in the Hull Botanic Garden to be thickly set, especially about the buds, with minute oval black eggs of some insect with which I was unacquainted, I brought home a small branch and set it in a jar of water in my study, in which is a fire daily, to watch their exclusion. On the 28th of March I observed that a numerous brood of Aphides (not *A. Betulæ*, as the wings were without the dark bands of that species) had been hatched from them, and that two or three of the lower buds had expanded into leaves, upon the sap of which they were greedily feasting. This was full a month before either a leaf of the birch appeared, or the egg of an Aphis was disclosed in the open air.—To view the relation of which I am speaking with due admiration, you must bear in mind the extremely different periods at which many trees acquire their leaves, and the consequent difference demanded in the constitution of the eggs which hybernate upon dissimilar species, to ensure their exclusion, though acted upon by the *same* temperature, earlier or later, according to the early or late foliation of these species. There is no visible difference between the conformation of the eggs of the Aphis of the birch and those of the Aphis of the ash; yet in the *same* exposure those of the former shall be hatched, simultaneously with

the expansion of the leaves, nearly a month earlier than those of the latter: thus demonstrably proving that the hybernation of these eggs is not accidental, but has been specially ordained by the Author of nature, who has conferred on those of each species a peculiar and appropriate organization.

A much greater number of insects pass the winter in the *pupa* than in the egg state; probably nine-tenths of the extensive order *Lepidoptera*, many in *Hymenoptera*, and several in other orders. In placing these pupæ in security from the too great cold of winter and the attacks of enemies, the larvæ from which they are to be metamorphosed exhibit an anxiety and ingenuity evidently imparted to them for this express design. A few are suspended without any covering, though usually in a sheltered situation. But by far the larger number are concealed under leaves, in the crevices or in the trunk of trees, &c., or inclosed in cocoons of silk or other materials which will be described to you in a subsequent letter, and often buried deep under ground out of the reach of frost.—One reason why so many lepidopterous insects pass the winter as pupæ, has been plausibly assigned by Rösel, in remarking that this is the case with all the numerous species which feed on annual plants. As these have no local habitation, dying one year and springing up from seed in another quarter the next, it is obvious that eggs deposited upon them in autumn would have no chance of escaping destruction; and that even if the larvæ were to be hatched before winter, and to hybernate in that state, they would have no certainty of being in the neighbourhood of their appropriate food the next spring. By wintering in the pupa state, these accidents are effec-

tually provided against. The perfect insect is not ready to break forth until the food of the young, which are to proceed from its eggs, is sprung up.

To the insects which hybernate in the *larva* state, of course belong, in the first place, all those which exist under that form more than one year; as many *Melolonthæ*, *Elateres*, *Cerambyces*, *Buprestes*, and several species of *Libellula*, *Ephemera*, &c. There are also many larvæ which, though their term of life is not a year, being hatched from the egg in autumn, necessarily pass the winter in that state, as those of several *Anobia* and other wood-boring insects; of *Tortrix Wœberana* and others of the same family; of the second broods of several butterflies, &c. Many of these residing in the ground or in the interior of trees need no other hybernacula than the holes which they constantly inhabit; some, as the aquatic larvæ, merely hide themselves in the sides or muddy bottom of their native pools; while others seek for a retreat under moss, dead leaves, stones, and the bark of decaying trees. Most of these can boast of no better winter quarters than a simple unfurnished hole or cavity; but a few, more provident of comfort, prepare themselves an artificial habitation. With this view the larva of *Bombyx Cossus*, L., as formerly observed in describing the habitations of insects[a], forms a covering of pieces of wood lined with fine silk; those of *Bombyx Humuli*, *Noctua radicea*, and some other moths, excavate under a stone a cavity exactly the size of their bodies, to which they give all round a coating of silk[b]; and the larvæ of *Papilio Cratægi* inclose themselves in autumn in cases of

[a] Vol. I. 4th Ed. 455. [b] Brahm, *Ins. Kal.* ii. 59. 118.

the same material[a], and thus pass the cold season in small societies of from two to twelve, under a common covering formed of leaves. Bonnet mentions a trait of the cleanliness of these insects which is almost ludicrous. He observed in one of these nests a sort of sack containing nothing but grains of excrement; and a friend assured him that he had seen one of these caterpillars partly protrude itself out of its case, the hind feet first, to eject a similar grain; so that it would seem the society have on their establishment a scavenger, whose business it is to sweep the streets and convey the rejectamenta to one grand repository[b]! This, however singular, is rendered not improbable from the fact that beavers dig in their habitations holes solely destined for a like purpose[c].

A very considerable number of insects hybernate in the *perfect* state, chiefly of the orders *Coleoptera*, *Hemiptera*, *Hymenoptera*, and *Diptera*, and especially of the first. *Papilio Urticæ*, *Io*, and a few other lepidopterous species, with a small proportion of the other orders, occasionally survive the winter; but the bulk of these are rarely found to hybernate as perfect insects. Of coleopterous insects, Schmid, to whom we are indebted for some va-

[a] I have reason to think that the larvæ of some species of *Hemerobius* thus protect themselves by a net-like case of silken threads; at least I found one to-day (December 3d, 1816) inclosed in a case of this description concealed under the bark of a tree: and it is not very likely that it could be a cocoon, both because the inhabitant was not a pupa, which state, according to Reaumur, is assumed soon after the cocoon is fabricated (iii. 385); and because the same author describes the cocoons of these insects as perfectly spherical and of a very close texture (384); while this was oblong, and the net-work with rather wide meshes.

[b] *Œuv.* ii. 72.

[c] *Ibid.* ix. 167.

luable remarks on the present subject[a], says that he never found or heard of any entomologist finding a hybernating individual of the common cockchafer (*Melolontha vulgaris*), or of the stag-beetle (*Lucanus Cervus*); and suggests that it is only those insects which exist but a short period as larvæ, as most of the tribe of *Curculionidæ*, *Coccinellidæ*, &c., that survive the winter in the perfect state; while those which live more than one year in the larva state, as the species just mentioned, are deprived of this privilege.

Towards the close of autumn the whole insect world, particularly the tribe of beetles, is in motion. A general migration takes place: the various species quit their usual haunts, and betake themselves in search of secure hybernacula. Different species, however, do not select precisely the same time for making this change of abode. Thus many *Coccinellæ*, *Cimices*, and *Muscidæ* are found out of their winter quarters even after the commencement of frost; while others, as Schmid has remarked, make good their retreat long before any severe cold has been felt: in fact, I am led to believe, from my own observations, that this is the case with the majority of coleopterous insects; and that the days which they select for retiring to their hybernacula, are some of the warmest days of autumn, when they may be seen in great numbers alighting on walls, rails, path-ways, &c. and running into crevices and cracks, evidently in search of some object very different from those which ordinarily guide their movements. I have noticed this assemblage in different years, but more particularly in the last autumn (1816). Walking on the

[a] Illig. *Mag*. i. 209-228.

banks of the Humber on the 14th of October about noon, —the day bright, calm, and deliciously mild, Fahrenheit's thermometer 58° in the shade,—my attention was first attracted by the path-ways swarming with numerous species of rove-beetles (*Staphylinus*, *Oxytelus*, *Aleochara*, &c.), which kept incessantly alighting, and hurrying about in every direction. On further examination I found a similar assemblage, with the addition of multitudes of other beetles, *Halticæ*, *Nitidulæ*, *Curculiones*, *Cryptophagi*, &c. on every post and rail in my walk, as well as on a wall in the neighbourhood; and on removing the decaying mortar and bark, I found that some had already taken up their abode in holes, from their situation with their antennæ folded, evidently meant for winter quarters. I am not aware that any author has noticed this remarkable congregation of coleopterous insects previously to hybernating, which it is so difficult to explain on any of the received theories of torpidity, except the pious Lesser, who so expressly alludes to it, and without quoting any other authority, that he would seem to have derived the fact from his own observation[a].

The site chosen by different perfect insects for their

[a] Lesser, *L.* i. 256.—Lyonet inserts a note to explain that Lesser's remark is to be understood only of such insects as live in societies; and adds, that solitary species do not assemble to pass the winter together. Lesser, however, says nothing about these insects passing the winter *together*, as his translator erroneously understands him; but merely that they assemble as if *preparing* to retire for the winter, which my own observations, as above, confirm. His expression in the original German is, "gleichsam als wenn sie sich zu ihrer winter-ruhe fertig machen wolten." Edit. Frankfurt und Leipsig 1738, p. 152.

hybernacula is very various. Some are content with insinuating themselves under any large stone, a collection of dead leaves, or the moss of the sheltered side of an old wall or bank. Others prefer for a retreat the lichen or ivy-covered interstices of the bark of old trees, the decayed bark itself, especially that near the roots, or bury themselves deep in the rotten trunk; and a very great number penetrate into the earth to the depth of several inches. The aquatic tribes, such as *Dytisci*, *Hydrophili*, &c. burrow into the mud of their pools; but some of these are occasionally met with under stones, bark, &c. In every instance the selected dormitory is admirably adapted to the constitution, mode of life, and wants of the occupant. Those insects which can bear considerable cold without injury, are careless of providing other than a slight covering; while the more tender species either enter the earth beyond the reach of frost, or prepare for themselves artificial cavities in substances such as moss and rotten wood, which conduct heat with difficulty, and defend them from an injuriously low temperature. It does not appear that any perfect insect has the faculty of fabricating for itself a winter abode similar to those formed of silk, &c. by some larvæ. Schmid, indeed, has mentioned finding *Rhagium mordax* and *Inquisitor*, F. in such abodes, constructed, as he thought, of the inner bark of trees; but these, as Illiger has suggested, were more probably the deserted dwellings of lepidopterous larvæ, of which the beetles in question had taken possession [a].—Most insects place themselves in their hybernacula in the attitude which they ordinarily

[a] Illig. *Mag.* i. 216.

assume when at rest; but others choose a position peculiar to their winter abode. So most of the *Carabidæ* adhere by their claws to the under side of the stone, which serves for their retreat, their backs being next to the ground; in which posture, probably, they are most effectually protected from wet. *Staphylinus sanguinolentus Gyrohypnus,* K.), Gravenhorst, and others of the same family, coils itself up like a snake, with the head in the centre.

The majority of insects pass the winter in perfect solitude. Occasionally, however, several individuals of one species, not merely of such insects as *Harpalus* (*Carabus,* L.) *prasinus*, *Cimex apterus*, &c., which usually in summer also live in a sort of society, but of others which are never seen thus to associate, as *Haltica oleracea*, *Carabus intricatus*, and several *Coccinellæ*, &c. are found crowded together. This is perhaps often more through accident than design, as individuals of the same species are frequently met with singly; yet that it is not wholly accidental, seems proved by the fact that such assemblages are generally of the same genus and even species. Sometimes, however, insects of dissimilar genera and even orders are met with together. Schmid once in February found the rare *Lomechusa strumosa*, Gravenhorst, (*Staphylinus*, L.) torpid in an ant-hill in the midst of a conglomerated lump of ants, with which it was closely intertwined[a].

By far the greater proportion of insects pass the winter only in one or other of the several states of egg, pupa, larva, or imago, but are never found to hybernate in *more* than one. Some species, however, depart from

[a] Illig. *Mag*. i. 491.

this rule. Thus *Aphis Rosæ*, *Cardui*, and probably many others of the genus, hybernate both in the egg and perfect state[a]; *Papilio Cardui*, *Rhamni*, and some other species, usually in the pupa, but often in the perfect state also; and *Papilio Io*, according to the accurate Brahm, in the three states of egg, pupa, and imago[b]. It is probable that in these instances the perfect insects are females, which, not having been impregnated, have their term of life prolonged beyond the ordinary period.

The first cold weather, after insects have entered their winter quarters, produces effects upon them similar to those which occur in the dormouse, hedgehog, and others of the larger animals subject to torpor. At first a partial benumbment takes place; but the insect if touched is still capable of moving its organs. But as the cold increases all the animal functions cease. The insect breathes no longer, and has no need of a supply of air[c]; its nutritive secretions cease, and no more food is required; the muscles lose their irritability[d]; and it has all the external symptoms of death. In this state it continues during the existence of great cold, but the degree of its torpidity varies with the temperature of the atmosphere. The recurrence of a mild day, such as we sometimes have in winter, infuses a partial animation into the stiffened animal: if disturbed, its limbs and antennæ resume their power of extension, and even the faculty of spirting out their defensive fluid is re-acquired by many beetles[e]. But however mild the atmosphere in

[a] Kyber in Germar *Magazin der Entomologie*, ii. 2.
[b] *Ins. Kal.* ii. 188. [c] Spallanzani, *Rapports de l'Air, &c.* i. 30.
[d] Carlisle in *Phil. Trans.* 1805, p. 25.
[e] Schmid in Illig. *Mag.* i. 222.

winter, the great bulk of hybernating insects, as if conscious of the deceptious nature of their pleasurable feelings, and that no food could then be procured, never quit their quarters, but quietly wait for a renewal of their insensibility by a fresh accession of cold.

On this head I have had an opportunity of making some observations which, in the paucity of recorded facts on the hybernation of insects, you may not be sorry to have laid before you. The second of December 1816 was even finer than many of the preceding days of the season, which so happily falsified the predictions that the unprecedented dismal summer would be followed by a severe winter. The thermometer was 46° in the shade; not a breath of air was stirring; and a bright sun imparted animation to troops of the winter gnat (*Trichocera hiemalis*, Meig.), which frisked under every bush; to numerous *Psychodæ;* and even to the flesh-fly, of which two or three individuals buzzed past me while digging in my garden. Yet though these insects, which I shall shortly advert to as exceptions to the general rule, were thus active, the heat was not sufficient to induce their hybernating brethren to quit their retreats. Removing some of the dead bark of an old apple-tree, I soon discovered several insects in their winter-quarters. Of the little beetle *Lebia quadrinotata*, Duftschmid *Faun. Austr.* (*Carabus punctomaculatus*, Ent. Brit.), I found six or eight individuals, and all so lively, that though remaining perfectly quiet in their abode until disturbed, they ran about with their ordinary activity as soon as the covering of bark was displaced. The same was the case with a colony of earwigs. Two or three individuals of *Lebia quadrimaculata* showed more

torpidity. When first uncovered their antennæ were laid back; and it was only after the sun had shone some seconds upon them that they exhibited symptoms of animation, and after stretching out these organs began to walk. Close by them lay a single *Rhynchænus Pomorum*, but in so deep a sleep that at first I thought it dead. It gave no sign of life when placed on my hand, quite hot with the exercise of digging; and it was only after being kept there some seconds, and breathed upon several times, that it first slowly unfolded its rostrum, and then its limbs. It deserves remark, that all these insects, thus differently affected, were on the same side of the tree, under a similar covering of bark, and apparently equally exposed to the sun, which shone full upon the covering of their retreat[a].

All insects, however, do not undergo this degree of torpidity. In fact, there are some, though but few, which

[a] Since writing the above, I have had another opportunity of confirming the observations here made. The last week of January 1817, in the neighbourhood of Hull, was most delicious weather—calm, sunny, dry, and genial—the wind south-west, the thermometer from 47° to 52° every day, and at night rarely below 40°; in fact, a week much finer than we can often boast of in May: the 27th of the month was the most delightful day of the whole: the air swarmed with *Trichocera hiemalis*, *Psychodæ*, and numerous other *Diptera*, and the bushes were hung with the lines of the gossamer-spider as in autumn. Yet, with the exception of *Aphodius contaminatus*, I did not observe a single coleopterous insect on the wing, nor even an individual tempted to crawl on the trunks of the trees, under the dead bark of which I found many in a very lively state. Five or six individuals of *Haltica Nemorum* were still very lethargic; and two of *Geotrupes stercorarius*, which I accidentally dug up from their hybernacula in the earth at the depth of six or eight inches, though the *Acari* upon them were quite alert, exhibited every symptom of complete torpor.

cannot, at least in our climate, strictly be said to hybernate, understanding by that term passing the winter in one selected situation in a greater or less degree of torpor, without food. Not to mention *Phalæna G. brumata*, and some other moths, which are disclosed from the pupæ in the middle of winter, and can therefore be scarcely regarded as exceptions to the rule, some insects are torpid only in very severe weather, and on fine mild days in winter come out to eat. This is the case with the larva of *Noctua fuliginosa*, L.[a]; and Lyonet asserts that there are many other caterpillars which eat and grow even in the midst of slight frost[b]. Amongst perfect insects, troops of *Trichocera hiemalis*, the gnat whose choral dances have been before described[c], may be constantly seen gamboling in the air in the depth of winter when it is mild and calm, accompanied by the little *Psychoda*, so common in windows, several *Muscidæ*, spiders, and occasionally some *Aphodii* and *Staphylinidæ:* and the societies of ants, as well as their attendant Aphides, are in motion and take more or less food during the whole of that season when the cold is not intense. The younger Huber informs us that ants become torpid only at 2° Reaum. below freezing (27° Fahrenheit), and apparently endeavour to preserve themselves from the cold, when its approach is gradual, by clustering together. When the temperature is above this point they follow their ordinary habits (he has seen them even walk upon the snow), and can then obtain the little food which they require in winter from their

[a] Brahm, *Ins. Kal.* ii. 31. [b] Lesser, *L.* i. 255.
[c] See above, p. 4. 372.

cows the Aphides, which, by an admirable provision, become lethargic at precisely the same degree of cold as the ants, and awake at the same period with them[a].

Lastly, there are some few insects which do not seem ever to be torpid, as *Podura nivalis*, L., and the singular apterous insect recently described by Dalman, *Chionea araneoïdes*[b], both of which run with agility on the snow itself; and the common hive-bee; though with regard to the precise state in which this last passes the winter, this part of its economy has not been made the subject of such accurate investigation as is desirable.

Many authors have conceived that it is the most natural state of bees in winter to be perfectly torpid at a certain degree of cold, and that their partial reviviscency, and consequent need of food in our climate, are owing to its variableness and often comparative mildness in winter; whence they have advised placing bees during this season in an ice-house, or on the north side of a wall, where the degree of cold being more uniform, and thus their torpidity undisturbed, they imagine no food would be required. So far, however, do these suppositions and conclusions seem from being warranted, that Huber expressly affirms that, instead of being torpid in

[a] *Recherches*, 202.—In digging in my garden on the 26th of January 1817, I turned up in three or four places colonies of *Myrmica rubra*, Latr. in their winter retreats, each of which comprised apparently one or two hundred ants, with several larvæ as big as a grain of mustard, closely clustered together, occupying a cavity the size of a hen's egg, in tenacious clay, at the depth of six inches from the surface. They were very lively; but though Fahrenheit's thermometer stood at 47° in the shade, I did not then, nor at any other time during the very mild winter, see a single ant out of its hybernaculum.

[b] Kongl. *Vet. Acad. Handling.* 1816. 104.

winter, the heat in a well-peopled hive continues + 24° or 25° of Reaumur (86° Fahrenheit), when it is several degrees below zero in the open air; that they then cluster together and keep themselves *in motion* in order to preserve their heat[a]; and that in the depth of winter they do not cease to ventilate the hive by the singular process of agitating their wings before described[b]. He asserts also that, like Reaumur, he has in winter found in the combs brood of all ages; which, too, the observant Bonnet says he has witnessed[c]; and which is confirmed by Swammerdam, who expressly states that bees tend and feed their young even in the midst of winter[d]. To all these weighty authorities may be added that of John Hunter, who, as before noticed, found a hive to grow lighter in a cold than in a warm week of winter; and that a hive from November 10th to February 9th lost more than four pounds in weight[e]; whence the conclusion seems inevitable, that bees do eat in winter.

On the other hand, Reaumur adopts (or rather, perhaps, has in great measure given birth to) the more commonly received notion, that bees in a certain degree of cold are torpid and consume no food. These are his words:—"It has been established with a wisdom which we cannot but admire,—with that wisdom with which every thing in nature has been made and ordained,—that during the greater part of the time in which the country furnishes nothing to bees, they have no longer need to eat. The cold which arrests the vegetation of plants, which deprives our fields and meadows of their flowers, throws the bees into a state in which nourish-

[a] Huber, i. 134. [b] Ibid. ii. 344. 358. See above, p. 194—
[c] Bonnet *On Bees*, 104. [d] Huber, i. 354. [e] *Phil. Trans.* 1790. 161.

ment ceases to be necessary to them: it keeps them in a sort of torpidity (*engourdissement*), in which no transpiration from them takes place; or, at least, during which the quantity of that which transpires is so inconsiderable, that it cannot be restored by aliment without their lives being endangered. In winter, while it freezes, one may observe without fear the interior of hives that are not of glass; for we may lay them on their sides, and even turn them bottom upwards, without putting any bee into motion. We see the bees crowded and closely pressed one against the other: little space then suffices for them[a]." In another place, speaking of the custom in some countries of putting bee-hives during winter into out-houses and cellars, he says that in such situations the air, though more temperate than out of doors during the greater part of winter, "is yet sufficiently cold to keep the bees in that species of torpidity which does away their need of eating[b]." And lastly, he expressly says that the milder the weather, the more risk there is of the bees consuming their honey before the spring, and dying of hunger; and confirms his assertion by an account of a striking experiment, in which a hive that he transferred during winter into his study, where the temperature was usually in the day 10° or 12° R. above freezing (59° F.), though provided with a plentiful supply of honey, that if they had been in a garden would have served them past the end of April, had consumed nearly their whole stock before the end of February[c].

Now, how are we to reconcile this contradiction?—for, if Huber be correct in asserting that in frosty weather

[a] Reaum. v. 667. [b] Ibid. 682. [c] Ibid. 668.

bees agitate themselves to keep off the cold, and ventilate their hive;—if, as both he and Swammerdam state they feed their young brood in the depth of winter—it seems impossible to admit that they ever can be in the torpid condition which Reaumur supposes, in which food, so far from being necessary, is injurious to them. In fact, Reaumur himself in another place informs us, that bees are so infinitely more sensible of cold than the generality of insects, that they perish when in numbers so small as to be unable to generate sufficient animal heat to counteract the external cold, even at 11° R. above freezing[a] (57° F.); which corresponds with what Huber has observed (as quoted above) of the high temperature of well-peopled hives, even in very severe weather. We are forced, then, to conclude that this usually most accurate of observers has in the present instance been led into error, chiefly, it is probable, from the clustering of bees in the hives in cold weather; but which, instead of being, as he conceived, an indication of torpidity, would seem to be intended, as Huber asserts, as a preservative against the benumbing effects of cold.

Bees, then, do not appear to pass the winter in a state of torpidity in our climates, and probably not in any others. Populous swarms inhabiting hives formed of the hollow trunks of trees, used in many northern regions, or of other materials that are bad conductors of heat, seem able to generate and keep up a temperature sufficient to counteract the intensest cold to which they are ordinarily exposed. At the same time, however, I think

[a] Reaum. 678. Compare also 673.

we may infer, that though bees are not strictly torpid at that lowest degree of heat which they can sustain, yet that when exposed to *that* degree they consume considerably less food than at a higher temperature; and consequently that the plan of placing hives in a north aspect in sunny and mild winters may be adopted by the apiarist with advantage. John Hunter's experiment, indeed, cited above, in which he found that a hive grew lighter in a cold than in a warm week, seems opposed to this conclusion; but an insulated observation of this kind, which we do not know to have been instituted with a due regard to all the circumstances that required attention, must not be allowed to set aside the striking facts of a contrary description recorded by Reaumur and corroborated by the almost universal sentiment of writers on bees.—After all, however, on this point, as well as on many others connected with the winter economy of these endlessly-wonderful insects, there is evidently much yet to be observed, and many doubts which can be satisfactorily dispelled only by new experiments.

The degree of cold which most insects in their different states, while torpid, are able to endure with impunity, is very various; and the habits of the different species, as to the situation which they select to pass the winter, are regulated by their greater or less sensibility in this respect. Many insects, though able to sustain a degree of cold sufficient to induce torpidity, would be destroyed by the freezing temperature, to avoid which they penetrate into the earth or hide themselves under non-conducting substances; and there can be little doubt that it is with this view that so many species while pupæ

are thus secured from cold by cocoons of silk or other materials. Yet a very great proportion of insects in all their states are necessarily subjected to an extreme degree of cold. Many eggs and pupæ are exposed to the air without any covering; and many, both larvæ and perfect insects, are sheltered too slightly to be secure from the frost. This they are either able to resist, remaining unfrozen though exposed to the severest cold, or, which is still more surprising, are uninjured by its intensest action, recovering their vitality even after having been frozen into lumps of ice.

The eggs of insects are filled with a fluid matter, included in a skin infinitely thinner than that of hens' eggs, which John Hunter found to freeze at about 15° of Fahrenheit. Yet on exposing several of the former, including those of the silk-worm, for five hours to a freezing mixture which made Fahrenheit's thermometer fall to 38° below zero, Spallanzani found that they were not frozen, nor their fertility in the slightest degree impaired. Others were exposed even to 56° below zero, without being injured[a].

A less degree of cold suffices to freeze many pupæ and larvæ, in both which states the consistency of the animal is almost as fluid as in that of the egg. Their vitality enables them to resist it to a certain extent, and it must be considerably below the freezing point to affect them. The winter of 1813-14 was one of the severest we have had for many years, Fahrenheit's thermometer having been more than once as low as 8° when the ground was wholly free from snow; yet almost the first objects which

[a] *Tracts*, 22.

I observed in my garden, in the commencement of spring, were numbers of the caterpillars of the gooseberry-moth (*Phalæna G. grossulariata*), which, though they had passed the winter with no other shelter than the slightly projecting rim of some large garden-pots, were alive and quite uninjured; and these and many other larvæ never in my recollection were so numerous and destructive as in that spring: whence, as well as from the corresponding fact secorded with surprise by Boerhaave, that insects abounded as much after the intense winter of 1709, during which Fahrenheit's thermometer fell to 0, as after the mildest season, we may see the fallacy of the popular notion, that hard winters are destructive to insects [a].

But though many larvæ and pupæ are able to resist a great degree of cold, when it increases to a certain extent they yield to its intensity and become solid masses of ice. In this state we should think it impossible that they should ever revive. That an animal whose juices, muscles, and whole body have been subjected to a process which splits bombshells, and converted into an icy mass that may be snapped asunder like a piece of glass, should ever recover its vital powers, seems at first view little less than a miracle; and, if the reviviscency of the wheel animal (*Vorticella rotatoria*) and of snails, &c. after years of desiccation, had not made us familiar with similar prodigies, might have been pronounced impossible; and it is probable that many insects when thus frozen never do revive. Of the fact, however, as to several species, there is no doubt. It was first noticed by Lister, who relates

[a] Vid. Spence in *Transactions of the Horticult. Soc. of London*, ii. 148. Compare Reaum. ii. 141.

that he had found caterpillars so frozen, that when dropped into a glass they chinked like stones, which nevertheless revived[a]. Reaumur, indeed, repeated this experiment without success; and found that when the larvæ of *Bombyx Pityocampa*, F. were frozen into ice by a cold of 15° R. below zero (2° F. below zero), they could not be made to revive[b]. But other trials have fully confirmed Lister's observations. My friend Mr. Stickney, before mentioned as the author of a valuable *Essay on the Grub* (larva of *Tipula oleracea*)—to ascertain the effect of cold in destroying this insect, exposed some of them to a severe frost, which congealed them into perfect masses of ice. When broken, their whole interior was found to be frozen. Yet several of these resumed their active powers. Bonnet had precisely the same result with the pupæ of *Papilio Brassicæ*, which, by exposing to a frost of 14° R. below zero (0° F.), became lumps of ice, and yet produced butterflies[c]. Indeed, the circumstance that animals of a much more complex organization than insects, namely, serpents and fishes, have been known to revive after being frozen, is sufficient to dispel any doubts on this head. John Hunter, though himself unsuccessful in his attempts to reanimate carp and other animals that had been frozen, confesses that the fact itself is so well authenticated as to admit of no question[d].

On what principle a faculty so extraordinary and so contrary to our common conceptions of the nature of animal life depends, I shall not attempt to explain. Nor can any thing very satisfactory be advanced with regard

[a] Lister, Goedart. *de Insectis*, 76. [b] Reaum. ii. 142.
[c] *Œuvres*, vi. 12. [d] *Observations on the Animal Economy*, 99.

to the source of the power which many insects in some states, and almost all in the egg state, have of resisting intense degrees of cold without becoming frozen. It is clear that the usual explanation of the same faculty to a less degree in the warm-blooded animals—the constant production of animal heat from the caloric set free in the decomposition of the respired air—will not avail us here. For, first, the hive-bee, which has the capacity of evolving animal heat in a much greater degree than any other insect, is killed by a cold considerably less than that of freezing. Secondly, many large larvæ, as Reaumur has observed, are destroyed by a less degree of cold than smaller species whose respiratory organization is necessarily on a much less extensive scale. And thirdly, the eggs of insects—in which, though they probably are in some degree acted upon by the oxygen of the atmosphere, nothing like respiration takes place—can endure a much greater intensity of cold than either the larvæ or pupæ produced from them.

Nor can we refer the effect in question to the thinness or thickness—the greater or less non-conducting power—of the skin of the animal. Reaumur found that the subterranean pupæ of many moths perished with a cold of 7° or 8° R. below zero (14° F.), while the exposed pupæ of *Papilio Brassicæ* and other species endured 15° or 16° without injury[a]; (a proof, by the way, that the different economy of these insects, as to their choice of a situation in their state of pupæ, is regulated by their power of resisting cold;) but no difference in the substance of the exterior skin is perceptible. And the eggs

[a] Reaum. ii. 146—

of insects have usually thinner skins than pupæ, and yet they are unaffected by a degree of cold much superior.

In the present state, then, of our knowledge of animal physiology, we must confess our ignorance of the cause of these phenomena, which seem never to have been sufficiently adverted to by general speculators on the nature of animal heat. We may conjecture, indeed, either that they are owing to some peculiar and varying attraction for caloric inherent in the fluids which compose the animal, and which in the egg state, like spirit of wine, resist our utmost producible artificial cold; or that, as John Hunter seems to infer with respect to a similar faculty in a minor degree in the hen's egg, the whole are to be referred to some unknown power of vitality. The latter seems the most probable supposition; for Spallanzani found that the blood of marmots, which remains fluid when they are exposed to a cold several degrees below zero of Fahrenheit, freezes at a much higher temperature when drawn from the animal[a]; and it is reasonable to conjecture that the same result would follow if the fluids filling the eggs of insects were collected separately, and then exposed to severe cold.

Spring is, of course, the period when insects shake off the four or five months' sleep which has sweetly banished winter from their calendar, quit their dormitories, and again enter the active scenes of life. It is impossible to deny that the increased temperature of this season is the immediate cause of their reappearance; for they leave their retreats much earlier in forward than in back-

[a] *Rapports de l'Air, &c.* ii. 215.

ward springs. Thus in the early spring of 1805 (to me a memorable one, since in it I began my entomological career, and had anxiously watched its first approaches in order to study practically the science of which I had gained some theoretical knowledge in the winter,) insects were generally out by the middle of March; and before the 30th, I find, on referring to my entomological journal, that I had taken and investigated (I scarcely need add, not always with a correct result,) fifty-eight coleopterous species: while in the last untoward spring (1816) I did not observe even a bee abroad until the 20th of April; and the first butterfly that I saw did not appear until the 26th.

There are, however, circumstances connected with this reappearance, which seem to prove that something *more* than the mere sensation of warmth is concerned in causing it. I shall not insist upon the remarkable fact which Spallanzani has noticed, that insects reāppear in spring at a temperature considerably lower than that at which they retired in autumn; because it may be plausibly enough explained by reference to their increased irritability in spring, the result of so long an abstinence from food, and their consequent augmented sensibility to the stimulus of heat. But if the mere perception of warmth were the sole cause of insects ceasing to hybernate, then we might fairly infer, that species of apparently similar organization, and placed in similar circumstances, would leave their winter quarters at the same time. This, however, is far from being the case. Reaumur observed that the larvæ of *Papilio Cinxia* quitted their nest a full month sooner than those of *Bombyx chrysorrhea*[a]. The reason is obvious; but cannot be referred to mere sen-

[a] Reaum. ii. 170.

sation. The former live on grass, and on the leaves of plantain, which they can meet with at the beginning of March—the period of their appearance: the latter eat only the leaves of trees which expand a month later. It might, indeed, be still contended, that this fact is susceptible of explanation by supposing that the organization of these two species of larva, though apparently similar, is yet in fact different, that of the one being constituted so as to be acted upon by a less degree of heat than that of the other: and this solution would be satisfactory if the torpidity of these larvæ were uninterrupted up to the very period at which they quit their nest. But facts do not warrant any such supposition. You have seen[a] than the temperature of a mild day even in winter awakens many insects from their torpidity, though without inducing them to leave their hybernacula; and it is therefore highly improbable that the larvæ of *B. chrysorrhea* should not often have their torpid state relaxed during the month of March, when we have almost constantly occasional bright days elevating the thermometer to above 50°. Yet as they still do not, like the larvæ of *P. Cinxia*, leave their nest, it seems obvious that something more than the sensation of heat is the regulator of the movements of each. Not, however, to detain you here unnecessarily, I shall not enlarge at present on this point, but shall pass on, in concluding this letter, to advert to the causes which have been assigned for the hybernation and torpidity of animals, and to state my own ideas on the subject, which will equally apply to the termination of this condition in spring.

[a] See above, 443-6.

The authors who have treated on these phenomena have generally[a] referred them to the operation of cold upon the animals in which they are witnessed, but acting in a different manner. Some conceive that cold combined with a degree of fatness arising from abundance of food in autumn, produces in them an agreeable sensation of drowsiness, such as we know, from the experience of Sir Joseph Banks and Dr. Solander in Terra del Fuego, as well as from other facts, is felt by man when exposed to a very low temperature; yielding to which, torpidity ensues. Others, admitting that cold is the cause of torpidity, maintain that the sensations which precede it are of a painful nature; and that the retreats in which hybernating animals pass the winter are selected in consequence of their endeavours to escape from the disagreeable influence of cold.

I have before had occasion to remark[b] the inconclusiveness of many of the physiological speculations of very eminent philosophers, arising from their ignorance of Entomology, which observation forcibly applies in the present instance. The reasoners upon torpidity have almost all confined their view to the hybernating quadrupeds, as the marmot, dormouse, &c., and have thus lost sight of the far more extensive series of facts supplied by hybernating insects, which would often at once have

[a] Here must be excepted my lamented friend the late Dr. Reeve of Norwich, who, in his ingenious *Essay on the Torpidity of Animals*, has come to nearly the same conclusion as is adopted in this letter; but, by omitting to make a distinction between torpidity and hybernation, he has not done justice to his own ideas.

[b] Vol. I. 4th Ed. 32.

set aside their most confidently-asserted hypotheses. If those who adopt the former of the opinions above alluded to, had been aware that numerous insects retire to their hybernacula (as has been before observed) on some of the finest days at the close of autumn, they could never have contended that this movement, in which insects display extraordinary activity, is caused by the agreeable *drowsiness* consequent on severe cold; and the very same fact is equally conclusive against the theory, that it is to escape the pain arising from a low temperature that insects bury themselves in their winter quarters.

In fact, the great source of the confused and unsatisfactory reasoning which has obtained on this subject, is, that no author, as far as my knowledge extends, has kept steadily in view, or indeed has distinctly perceived, the difference between torpidity and hybernation; or, in other words, between the *state* in which animals pass the winter, and their *selection* of a *situation* in which they may become subject to that state.

That the torpidity of insects, as well as of other hybernating animals, is caused by cold, is unquestionable. However early the period at which a beetle, for example, takes up its winter quarters, it does not suffer that cessation of the powers of active life which we understand by torpidity, until a certain degree of cold has been experienced; the degree of its torpidity varies with the variations of temperature; and there can be no doubt that, if it were kept during winter from the influence of cold, it would not become torpid at all—at least this has proved the fact with marmots and dormice thus treated; and the Aphis of the rose (*A. Rosæ*), which becomes tor-

pid in winter in the open air[a], retains its activity and gives birth to a numerous progeny upon rose trees preserved in greenhouses and warm apartments.

But, can we, in the same way, regard mere cold as the cause of the *hybernation* of insects? Is it wholly owing to this agent, as most writers seem to think—to feelings either of a pleasurable or painful nature produced by it—that *previously* to becoming torpid they select or fabricate commodious retreats precisely adapted to the constitution and wants of different species, in which they quietly wait the accession of torpidity and pass the winter? In my opinion, certainly not.

In the first place, if sensations proceeding from cold lead insects to select retreats for hybernating, how comes it that, as above shown, a large proportion of them enter these retreats before any severe cold has been felt, and on days considerably warmer than many that preceded them? If this supposition have any meaning, it must imply that insects are so constituted that, when a certain degree of cold has been felt by them, the sensations which this feeling excites impel them to seek out hybernacula. Now the thermometer in the shade on the 14th of October 1816, when I observed vast numbers thus employed, was at 58°—this then, on the theory in question, is a temperature sufficiently low to induce the requisite sensations. But it so happens, as I learn from my meteorological journal (which registers the greatest and least daily temperature as indicated by a Six's thermometer), that on the 31st of August 1816 the greatest

[a] Kyber in Germar's *Mag. der Ent.* ii. 3.

heat was not more than 52°, or six degrees lower than on the 14th of October: yet it was six weeks later that insects retired for the winter!

But it may be objected, that it is perhaps not so much the precise degree of cold prevailing on the day when insects select their hybernacula, that regulates their movements, as the lower degree which may have obtained for a few nights previously, and which may act upon their delicate organization so as to influence their future proceedings. Facts, however, are again in direct opposition to the explanation; for I find that, for a week previously to the 14th of October 1816, the thermometer was never lower at night than 48°, while in the first week of August it was twice as low as 46°, and never higher than 50°.[a]

As a last resource, the advocates of the doctrine I am opposing, may urge, that possibly insects may even have

[a] Since the publication of the first edition of this volume, I have had an opportunity of making some observations which strongly corroborate the above reasoning. The month of October in the present year (1817) set in extremely cold. From the first to the sixth piercing north and north-west winds blew; the thermometer at Hull, though the sun shone brightly, in the day-time was never higher than from 52° to 56°, nor at night than 38°; in fact, on the first and third it sunk as low as 34°, and on the second to 31°: and on those days, at eight in the morning, the grass was covered with a white hoar frost; in short, to every one's feelings the weather indicated December rather than October. Here then was every condition fulfilled that the theory I am opposing can require; consequently, according to that theory, such a state of the atmosphere should have driven every hybernating insect to its winter quarters. But so far was this from being the case, that on the fifth, when I made an excursion purposely to ascertain the fact, I found all the insects still abroad which I had met with six weeks before in similar situations.

their sensations affected by the cold some days *before* it comes on, in the same way as we know that spiders and some other animals are influenced by changes of weather previously to their actual occurrence. But once more I refer to my meteorological journal; and I find that the average lowest height of the thermometer, in the week comprising the latter end of October and beginning of November 1816, was $43\frac{1}{7}°$; while in the week comprising the same days of the month of the end of August and beginning of September it was only $44\frac{5}{7}°$—a difference surely too inconsiderable to build a theory upon.

I have entered into this tedious detail, because it is of importance to the spirit of true philosophizing to show what little agreement there often is between facts and many of the hypotheses, which authors of the present day are, from their determination to explain every thing, led to promulgate. But in truth there was no absolute need for imposing this fatigue upon your attention; for the single notorious consideration that in this climate, as well as in more southern ones, we not unfrequently have sharp night-frosts in summer, and colder weather at that season than in the latter end of autumn and beginning of winter, and yet that insects *do* hybernate at the latter period, but do *not* at the former, is an ample refutation of the notion that mere cold is the cause of the phenomenon. If, indeed, the hybernacula of insects were simply the underside of any dead leaf, clod, or stone, that chanced to be in the neighbourhood of their abode, it might still be contended, that such situations were *always* resorted to by them on the occurrence of a certain degree of cold, but that they remained in them only

when its continuance had induced torpidity: and it seems to have been in this view that most reasoners on this subject have regarded the hybernation of the larger animals, to which they have exclusively directed their attention. But had they been acquainted (as surely the investigators of such a question ought to have been) with the economy of the class of insects, in which not merely a few species, as among quadrupeds, but ninety-nine hundredths of the whole, in our climates, hybernate, they would have known that their hybernacula are in general totally distinct from their ordinary retreats in casual cold weather; and that many of them even fabricate habitations requiring considerable time and labour, expressly for the purpose of their winter residence—which last fact in particular, on their theory, admits of no satisfactory explanation. We may say, and truly, that the sensation of fatigue causes man to lie down and sleep; but we should laugh at any one who contended that this sensation forced him first to make a four-post bedstead to repose upon.

In the second place, if we grant for a moment that it is cold which drives insects to their hybernacula, there are other phenomena attending the state of hybernation which on this supposition are inexplicable. If cold led insects to enter their winter quarters, then they ought to be led by the cessation of cold to quit them. But, as has been before observed, we have often days in winter milder than at the period of hybernating, and in which insects are so roused from their torpidity as to run about nimbly when molested in their retreats; yet though their irritability must have been increased by a two or three months

inactivity and abstinence, they do not leave them, but quietly remain until a fresh accession of cold again induces insensibility.

In short, to refer the hybernation of insects to the mere direct influence of cold, is to suppose one of the most important acts of their existence given up to the blind guidance of feelings which in the variable climates of Europe would be leading them into perpetual and fatal errors—which in spring would be inducing them to quit their ordinary occupations, and prepare retreats and habitations for winter to be quitted again as soon as a few fine days had dispelled the frosty feel of a May week; and in a mild winter's day, when the thermometer, as is often the case, rises to 50° or 55°, would lure them to an exposure that must destroy them. It is not, we may rest assured, to such a deceptious guide that the Creator has intrusted the safety of so important a part of his creatures: their destinies are regulated by feelings far less liable to err.

What, you will ask, is this regulator? I answer *Instinct*—that faculty to which so many other of the equally surprising actions of insects are to be referred; and which alone can adequately account for the phenomena to be explained. Why, indeed, should we think it necessary to go further? We are content to refer to instinct, the retirement of insects into the earth previously to becoming pupæ, and the cocoons which they then fabricate; and why should we not attribute to the same energy, their retreat into appropriate hybernacula, and the construction by many species of habitations expressly destined for their winter residence! The cases

are exactly analogous; and the insect knows no more that its hybernaculum is to protect it from too severe a degree of cold during winter, than does the full-fed caterpillar when it enters the earth that it shall emerge a glorious butterfly.

I am, &c.

LETTER XXVII.

ON THE INSTINCT OF INSECTS.

THE greater part of those surprising facts connected with the manners and economy of insects, of which the relation has occupied the preceding letters, is to be referred, I have told you, to their instinct. But *what*, you will ask, is this instinct?—of what nature is this faculty which produces effects so extraordinary?

To this query I do not pretend to give any satisfactory answer. As I am quite of Bonnet's opinion, that philosophers will in vain torment themselves to define instinct, until they have spent some time in the head of an animal without actually *being* that animal—a species of metempsychosis through which I have never passed—I shall not attempt to explain what this mysterious energy *is*. It will not, however, I imagine, be very difficult to show what it is *not*; and some observations with this view, followed by an enumeration of peculiarities which distinguish the instincts of insects from those of other tribes of animals, and a short inquiry whether their actions are guided solely by instinct, will form the substance of this letter.

I. It is quite superfluous at this day to controvert the explanations of instinct advanced by some of the philosophers of the old school, such as that of Cudworth, who referred this faculty to a certain *plastic nature*; or that of Des Cartes, who contended that animals are mere *machines*. Nor, I fancy, would you thank me for entering into an elaborate refutation of the doctrine of Mylius, that many of the actions deemed instinctive are the effect of painful corporeal feelings; the cocoon of a caterpillar, for instance, being the result of a fit of the colic, produced by a superabundance of the gum which fills its silk-bags, and which exuding, is twisted round it, by its uneasy contortions, into a regular ball. Still less need I advert to the notable discovery of some pupils of Professor Winckler, that the brain, alias the soul, of a bee or spider, is impressed at the birth of the insect with certain geometrical figures, according to which models its works are constructed,—a position which these gentlemen demonstrate very satisfactorily by a memorable experiment in which they themselves were able to *hear triangles*.

It is as unnecessary to waste any words in refutation of the nonsense (for it deserves no better name) of Buffon, who refers the instinct of societies of insects to the circumstance of a great number of individuals being brought into existence at the same time, all acting with equal force, and obliged by the similarity of their internal and external structure, and the conformity of their movements, to perform each the same actions, in the same place, in the most convenient mode for themselves, and least inconvenient for their companions; whence results a regular, well-proportioned, and symmetrical

structure: and he gravely tells us that the boasted hexagonal cells of bees are produced by the reciprocal pressure of the cylindrical bodies of these insects against each other [a]!!

Nor is it requisite to advert at length to the explanations of instinctive actions more recently given by Steffens, a German author (one of the transcendentalists, I conclude, from the incomprehensibility of his book to my ordinary intellect), who says that the products of the vaunted instinct of insects are nothing but "shootings out of inorganic animal masses" (*anorgische anschüsse*)[b]; and by Lamarck[c], who attributes them to certain inherent inclinations arising from habits impressed upon the organs of the animals concerned in producing them, by the constant efflux towards these organs of the nervous fluid, which during a series of ages has been displaced in their endeavours to perform certain actions which their necessities have given birth to. The mere statement of an hypothesis of which the enunciation is nearly unintelligible, and built upon the assumption of the presence of an unseen fluid, and of the existence of the animal some millions of years, is quite sufficient, and would even be unnecessary if it were not of such late origin. Neither shall I detain you with any formal consideration of the hypothesis advanced by Addison and

[a] *Hist. Nat.* Edit. 1785, v. 277.

[b] *Beiträge zur innern Naturgeschichte der Erde* 1801, p. 298.

[c] In his *Philosophie Zoologique*, Paris 1809 (ii. 325)—a work which every zoologist will, I think, join with me in regretting should be devoted to metaphysical disquisitions built on the most gratuitous assumptions, instead of comprising that luminous generalization of *facts* relative to the animal world which is so great a disideratum, and for performing which satisfactorily this eminent naturalist is so well qualified.

some other authors, that instinct is an immediate and constant impulse of the Deity; which, to omit other obvious objections, is sufficiently refuted by the fact, that animals in their instincts are sometimes at fault, and commit mistakes, which on the above supposition could not in any case happen.

The only doctrine on the subject of instinct requiring any thing like a formal refutation, is that which, contending for the identity of this faculty with reason in man, maintains that all the actions of animals, however complicated, are, like those of the human race, the result of observation, invention, and experience. This theory, maintained by the sceptics, Pythagoras, Plato, and some other ancient philosophers, and in modern times by Helvetius, Condillac, and Smellie, has been by none more ingeniously supported than by Dr. Darwin, who in the chapter treating on instinct, in the first volume of *Zoonomia*, has brought forward a collection of facts which give it a great air of plausibility. This plausibility, however, is merely superficial; and the result of a rigorous examination by any competent judge is, that the greater part of Dr. Darwin's facts bear more strongly in favour of the dissimilarity of instinct and reason than of their identity: and that those few which seem to support the latter position, are built upon the relations of persons ignorant of natural history, who have confused together distinct species of animals. Thus, because some anonymous informant told him that hive-bees when transported to Barbadoes, where there is no winter, ceased to lay up a store of honey, Dr. Darwin infers that all the operations of these insects are guided by reason and the adaptation of means to an end—a very

just inference, if the statement from which it is drawn were accurate; but that it is not so, is known to every naturalist acquainted with the fact that many different species of bees store up honey in the hottest climates; and that there is no authentic instance on record of the hive-bees' altering in any age or climate their peculiar operations, which are now in the coldest and in the hottest regions precisely what they were in Greece in the time of Aristotle, and in Italy in the days of Virgil. Indeed the single fact, depending on the assertions of such accurate observers as Reaumur and Swammerdam, that a bee as soon after it is disclosed from the pupa as its body is dried and its wings expanded, and before it is possible that it should have received any instruction, betakes itself to the collecting of honey or the fabrication of a cell, which operations it performs as adroitly as the most hoary inhabitant of the hive, is alone sufficient to set aside all the hear-say statements of Dr. Darwin, and should have led him, as it must every logical reasoner, to the conclusion, that these and similar actions of animals cannot be referred to any reasoning process, nor be deemed the result of observation and experience.—It is true, it does not follow that animals, besides instinct, have not, in a degree, the faculty of reason also; and as I shall in the sequel endeavour to show, many of the actions of insects can be adequately explained on no other supposition. But to deny, as Dr. Darwin does, that the art with which the caterpillar weaves its cocoon, or the unerring care with which the moth places her eggs upon food that she herself can never use, are the effects of instinct, is as unphilosophical and contrary to fact, as to insist that the eagerness with which, though

it has never tasted milk, the infant seeks for its mother's breast, is the effect of reason.

Instinct, then, is *not* the result of a plastic nature; of a system of machinery; of diseased bodily action; of models impressed on the brain; nor of organic shootings-out:—it is not the effect of the habitual determination for ages of the nervous fluid to certain organs; nor is it either the impulse of the Deity, or reason. Without pretending to give a logical definition of it, which while we are ignorant of the essence of reason is impossible, we may call the instincts of animals those unknown faculties implanted in their constitution by the Creator, by which, independent of instruction, observation, or experience, and without a knowledge of the end in view, they are impelled to the performance of certain actions tending to the well-being of the individual and the preservation of the species: and with this description, which is in fact merely a confession of ignorance, we must, in the present state of metaphysical science, content ourselves.

I here say nothing of that supposed connexion of the instinct of animals with their *sensations*, which has been introduced into many definitions of this mysterious power, for two reasons. In the first place, this definition merely sets the world upon the tortoise; for what do we know more than before about the nature of instinct, when we have called it, with Brown, a predisposition to certain actions when certain sensations exist, or with Tucker have ascribed it to the operation of the senses, or to that internal feeling called appetite? But, secondly, this connexion of instinct with bodily sensation, though probable enough in some instances, is by no means generally evident. We may explain in this way the instincts

connected with hunger and the sexual passion, and some other particular facts, as the laying of the eggs of the flesh-fly in the flowers of *Stapelia hirsuta*, instead of in carrion their proper nidus, and of those of the common house-fly in snuff[a] instead of dung; for in these instances the smell seems so clearly the guide, that it even leads into error. But what connexion between sensation and instinct do we see in the conduct of the working-bees, which fabricate some of the cells in a comb larger than others, expressly to contain the eggs and future grubs of drones, though these eggs are not laid by themselves, and are still in the ovaries of the queen? So, we may plausibly enough conjecture that the fury with which, in ordinary circumstances, at a certain period of the year, the working-bees are inspired towards the drones, is the effect of some disagreeable smell or emanation proceeding from them at that particular time: but how can we explain, on similar grounds, the fact that in a hive deprived of a queen, no massacre of the drones takes place? Lastly, to omit here a hundred other instances, as many of them will be subsequently adverted to, if we may with some show of reason suppose that it is the sensation of heat which causes bees to swarm; yet what possible conception can we form of its being bodily sensations that lead bees to send out scouts in search of a hive suitable for the new colony, several days *before* swarming?

After these observations on the nature of instinct, generally, I pass on to contrast in several particulars the

[a] Dr. Zinken genannt Sommer says, that if in August and September a snuff-box be left open, it will be seen to be frequented by the common house-fly (*Musca domestica*), the eggs of which will be found to have been deposited amongst the snuff. Germar *Mag. der Ent.* I. ii. 189.

instincts of insects with those of other animals; and thus to bring together some remarkable instances of the former which have not hitherto been laid before you, as well as to deduce from some of those already related, inferences to which it did not fall in with my design before to direct your attention. This contrast may be conveniently made under the three heads of—the exquisiteness of their instincts—their number—and their extraordinary development.

The instincts of by far the majority of the superior animals are of a very simple kind, only directing them to select suitable food; to propagate their species; to defend themselves and their young from harm; to express their sensations by various vocal modulations; and to a few other actions which need not be particularized. Others of the larger animals, in addition to these simpler instinctive propensities, are gifted with more extensive powers; storing up food for their winter consumption, and building nests or habitations for their young, which they carefully feed and tend.

All these instincts are common to insects, a great proportion of which are in like manner confined to these. But a very considerable number of this class are endowed with instincts of an *exquisiteness* to which the higher animals can lay no claim. What bird or fish, for example, catches its prey by means of nets as artfully woven and as admirably adapted to their purposes as any that ever fisherman or fowler fabricated? Yet such nets are constructed by the race of spiders. What beast of prey thinks of digging a pit-fall in the track of the animals which serve it for food, and at the bottom of which it conceals itself, patiently waiting until some unhappy

victim is precipitated down the sides of its cavern? Yet this is done by the ant-lion and another insect. Or, to omit the endless instances furnished by wasps, ants, the Termites, &c., what animals can be adduced which, like the hive-bee associating in societies, build regular cities composed of cells formed with geometrical precision, divided into dwellings adapted in capacity to different orders of the society, and storehouses for containing a supply of provision? Even the erections of the beaver, and the pensile dwelling of the tailor-bird, must be referred to a less elaborate instinct than that which guides the procedures of these little insects—the complexness and yet perfection of whose operations, when contrasted with the insignificance of the architect, have at all times caused the reflecting observer to be lost in astonishment.

It is, however, in the *deviations* of the instincts of insects and their *accommodation to circumstances*, that the exquisiteness of these faculties is most decidedly manifested. The instincts of the larger animals seem capable of but slight modification. They are either exercised in their full extent or not at all. A bird, when its nest is pulled out of a bush, though it should be laid uninjured close by, never attempts to replace it in its situation; it contents itself with building another. But insects in similar contingencies often exhibit the most ingenious resources, their instincts surprisingly accommodating themselves to the new circumstances in which they are placed, in a manner more wonderful and incomprehensible than the existence of the faculties themselves. Take a honey-comb, for instance. If *every* comb that bees fabricate were *always* made *precisely* alike—with the same general form, placed in the same

position, the cells all exactly similar, or where varying with the variations always alike;—this structure would perhaps in reality be not more astonishing than many of a much simpler conformation. But when we know that in nine instances out of ten the combs in a bee-hive are thus similar in their properties, and yet that in the tenth one shall be found of a form altogether peculiar; placed in a different position; with cells of a different shape—and all these variations evidently adapted to some new circumstance not present when the other nine were constructed,—we are constrained to admit that nothing in the instinct of other animals can be adduced, exhibiting similar exquisiteness: just as we must confess an ordinary loom, however ingeniously contrived, far excelled by one capable of repairing its defects when out of order.

The examples of this variation and accommodation to circumstances among insects are very numerous; and as presenting many interesting facts in their history not before related, I shall not fear wearying you with a pretty copious detail of them, beginning with the more simple.

It is the instinct of *Geotrupes vernalis* to roll up pellets of dung, in each of which it deposits one of its eggs; and in places where it meets with cow- or horse-dung only, it is constantly under the necessity of having recourse to this process. But in districts where sheep are kept, this beetle wisely saves its labour, and ingeniously avails itself of the pellet-shaped balls ready made to its hands which the excrement of these animals supplies[a].

A caterpillar described by Bonnet, which from being confined in a box was unable to obtain a supply of the

[a] Sturm, *Deutschlands Fauna*, i. 27.

bark with which its ordinary instinct directs it to make its cocoon, substituted pieces of paper that were given to it, tied them together with silk, and constructed a very passable cocoon with them.—In another instance the same naturalist having opened several cocoons of a moth (*Noctua Verbasci*, F.), which are composed of a mixture of grains of earth and silk, just after being finished; the larvæ did not repair the injury in the same manner. Some employed both earth and silk; others contented themselves with spinning a silken veil before the opening[a].

The larva of the cabbage-butterfly (*Papilio Brassicæ*, L.) when about to assume the pupa state, commonly fixes itself to the under-side of the coping of a wall or some similar projection. But the ends of the slender thread which serves for its girth would not adhere firmly to stone or brick, or even wood. In such situations, therefore, it previously covers a space of about an inch long and half an inch broad with a web of silk, and to this extensive base its girth can be securely fastened. That this proceeding, however, is not the result of a blind unaccommodating instinct, seems proved by a fact which has come under my own observation. Having fed some of these larvæ in a box covered by a piece of muslin, they attached themselves to this covering; but as its texture afforded a firm hold to their girth, they span *no* preparatory web.

Apis Muscorum, L., and some other species of humble-bees cover their nests with a roof of moss. M. P. Huber having placed a nest of the former under a bell glass, he

[a] *Œuvres*, ii. 238. See above, p. 259.

stuffed the interstices between its bottom and the irregular surface on which it rested, with a linen cloth. This cloth, the bees, finding themselves in a situation where no moss was to be had, tore thread from thread, carded it with their feet into a felted mass, and applied it to the same purpose as moss, for which it was nearly as well adapted.—Some other humble-bees tore the cover of a book with which he had closed the top of the box that contained them, and made use of the detached morsels in covering their nest[a].

The larva of *Bombyx Cossus*, L., which feeds in the interior of trees, previously to fabricating a cocoon and assuming the pupa state, forms for the egress of the future moth a cylindrical orifice, except when it finds a suitable hole ready made. When the moth is about to appear, the chrysalis with its anterior end forces an opening in the cocoon. If the orifice in the tree has been formed by itself, in which case it exactly fits its body, it *entirely* quits the cocoon, and pushes itself half way out of the hole, where it remains secure from falling until the moth is disclosed. But if the orifice, having been adopted, be larger than it ought to have been, and thus not capable of supporting the pupa in this position, the provident insect pushes itself only *half way* out of the cocoon, which thus serves for the support which in the former case the wood itself afforded[b].

The variations in the procedures of the larva of a little moth (*Tinea*, F.) described by Reaumur, whose habitation has been before noticed[c]—one of those which constantly reside in a subcylindrical case—are still more

[a] *Linn. Trans.* vi. 254—. [b] Lyonet, *Traité anatomique* &c. 16—.
[c] Vol. I. 4th Ed. 458—.

remarkable. This little caterpillar feeds upon the elm, the leaves of which serve it at once for food and clothing. It eats the parenchyma or inner pulp, burrowing between the upper and under membranes, of portions of which cut out, and properly sewed together, it forms its case. Its usual plan is, to insinuate itself between the epidermal membranes of the leaf, close to one of the edges. Parallel with this it excavates a cavity of suitable form and dimensions, gnawing the pulp even out of every projection of the serratures, but carefully avoiding to separate the membranes at the very edge, which with a wise saving of labour it intends should form one of the seams of its coat; and as the little miner is not embarrassed with the removal of the excavated materials, which it swallows as it proceeds, a cavity sufficiently large is but the work of a few hours. It then lines it with silk, at the same time pushing it into a more cylindrical shape; and lastly, cutting it off at the two ends and inner side, it sews up the latter with such nicety that the suture is scarcely discoverable; and is now provided with a case or coat exactly fitting its body, open at the two ends, by one of which it feeds and by the other discharges its excrement, having on one side a nicely-joined seam, and the other—that which is commonly applied to its back—composed of the natural marginal junction of the membranes of the leaf.

Such are the ordinary operations of this insect, which, when it is considered that the case is rather fusiform than cylindrical; that the end through which it eats is circular, and the other curiously three-cornered like a cocked-hat; and that consequently its cloth requires to be very irregularly and artfully cut, to be accommodated to such a figure—it must be admitted, are the result of an instinct

of no very simple kind. Complicated, however, as these manœuvres seem, our ingenious workman is not confined to them. By way of putting its resources to the test, Reaumur cut off the serrated edge from the nearly-finished coat of one of them, and exposed the little occupant to the day. He expected that it would have quitted its mutilated garment and commenced another; and so it certainly would, had it been guided by an invariable instinct. But he calculated erroneously. Like one of its brother tailors of the biped race, it knew how "to cut its coat according to its cloth," and immediately setting about repairing the injury sewed up the rent. Nor was this all. The scissars having cut off one of the projections intended to enter into the construction of the triangular end of its case, it entirely changed the original plan, and made that end the head which had been first designed for the tail.

On another occasion Reaumur observed one of these larvæ to cut out its coat from the very centre of a leaf, where it is obvious a series of operations wholly different must be adopted, the two membranes composing it necessarily requiring to be cut and sewed on *two* sides instead of on one only. But what was most striking in this new procedure was the alteration which the caterpillar made in the period of sewing up its garment. When these larvæ cut out their case from the edge of a leaf, they seem aware that, if they were to detach it entirely from the inner side before the process of sewing, lining, &c., is completed, having no support on the exterior edge, it would be liable to fall down; at the same time they could not sew together the membranes composing it at the *inner* side, without cutting them in part from the leaf.

While, therefore, they divide the major part of their inner side from the leaf, they artfully leave them attached to it by one of the large nerves at each end: and these supports they do not cut asunder until the intermediate space has been sewed up, and they are ready to step, with their house on their back, upon the *terra firma* of the disk of the leaf. In this instance, therefore, the larvæ do not wholly separate their case from the leaf, until it is sewed. But when the same larvæ cut out their materials from the middle of the leaf, where, though completely cut round, they are retained in their situation secure from all danger of falling by the serratures of the incisions made by the jaws of the larvæ, these little tailors vary their mode, and *entirely* detach the pieces from the surronding leaf, before they proceed to set a stitch into them[a].

In the preceding instances the variation of instinct takes place in the same individual, but Bonnet mentions a very curious fact in which it occurs in different generations of the same species. There are annually, he informs us, two generations of the Angoumois moth, an insect which has been before mentioned[b], as destructive to wheat: the first appear in May and June, and lay their eggs upon the ears of wheat in the fields; the second appear at the end of the summer or in autumn, and these lay their eggs upon wheat in the granaries. These last pass the winter in the state of larvæ, from which proceeds the first generation of moths. But what is extremely singular as a variation of instinct, those moths which are disclosed in *May* and *June* in the granaries, quit them with a rapid flight at sun-set, and betake themselves to

[a] Reaum. iii. 112-119. [b] Vol. I. 4th Ed. 171.

the yet unreaped fields, where they lay their eggs; while the moths which are disclosed in the granaries after harvest, stay there, and never attempt to go out, but lay their eggs upon the stored wheat [a].—This is as extraordinary and inexplicable as if a litter of rabbits produced in spring were impelled by instinct to eat vegetables, while another produced in autumn should be as irresistibly directed to choose flesh.

It is, however, into the history of the hive-bee that we must look for the most striking examples of variation of instinct; and here, as in every thing relating to this insect, the work of the elder Huber is an unfailing source of the most novel and interesting facts.

It is the ordinary instinct of bees to lay the foundation of their combs at the top of the hive, building them perpendicularly *downwards*; and they pursue this plan so constantly, that you might examine a thousand (probably ten thousand) hives, without finding any material deviation from it. Yet Huber in the course of his experiments forced them to build their combs perpendicularly upward [b]; and, what seems even more remarkable, in an horizontal direction [c].

The combs of bees are always at an uniform distance from each other, namely about one third of an inch, which is just wide enough to allow them to pass easily and have access to the young brood. On the approach of winter, when their honey-cells are not sufficient in number to contain all the stock, they *elongate* them considerably, and thus increase their capacity. By this extension the intervals between the combs are unavoidably

[a] *Œuvres*, ix. 370. [b] Huber, ii. 134—. [c] Ibid. ii. 216.

contracted; but in winter well-stored magazines are essential, while from their state of comparative inactivity spacious communications are less necessary. On the return of spring, however, when the cells are wanted for the reception of eggs, the bees contract the elongated cells to their former dimensions, and thus re-establish the just distances between the combs which the care of their brood requires[a]. But this is not all. Not only do they elongate the cells of the old combs when there is an extraordinary harvest of honey, but they actually give to the new cells which they construct on this emergency a much greater *diameter* as well as a greater depth[b].

The queen-bee in ordinary circumstances places each egg in the centre of the pyramidal bottom of the cell, where it remains fixed by its natural gluten: but in an experiment of Huber, one whose fecundation had been retarded, had the first segments of her abdomen so swelled that she was unable to reach the bottom of the cells. She therefore attached her eggs (which were those of males) to their lower side, two lines from the mouth. As the larvæ always pass that state in the place where they are deposited, those hatched from the eggs in question remained in the situation assigned them. But the working-bees, as if aware that in these circumstances the cells would be too short to contain the larvæ when fully grown, *extended their length*, even before the eggs were hatched[c].

Bees close up the cells of the grubs, previously to their transformation, with a cover or lid of wax: and in hanging its abode with a silken tapestry before it assumes the pupa state, the grub requires that the cell should not be too short for its movements. Bonnet having placed a

[a] Ibid. i. 348. [b] Ibid. ii. 227. [c] Huber, i. 119.

swarm in a very flat glass hive, the bees constructed one of the combs parallel to one of the principal sides, where it was so straight that they could not give to the cells their ordinary depth. The queen, however, laid eggs in them, and the workers daily nourished the grubs, and closed the cells at the period of transformation. A few days afterwards he was surprised to perceive in the lids, holes more or less large, out of which the grubs partly projected, the cells having been too short to admit of their usual movements. He was curious to know how the bees would proceed. He expected that they would pull all the grubs out of the cells, as they commonly do when great disorders in the combs take place. But he did not sufficiently give credit to the resources of their instinct. They did not displace a single grub—they left them in their cells: but as they saw that these cells were not deep enough, they closed them afresh with lids much more convex than ordinary, so as to give to them a sufficient depth; and from that time no more holes were made in the lids.

The working bees, in closing up the cells containing larvæ, invariably give a convex lid to the large cells of drones, and one nearly flat to the smaller cells of workers: but in an experiment instituted by Huber to ascertain the influence of the size of the cells on that of the included larvæ, he transferred the larvæ of workers to the cells of drones. What was the result? Did the bees still continue blindly to exercise their ordinary instinct? On the contrary, they now placed a nearly *flat* lid upon these large cells, as if well aware of their being occupied by a different race of inhabitants [a].

[a] Huber, i. 233.

On some occasions bees, in consequence of Huber's arrangements in the interior of their habitations, have begun to build a comb nearer to the adjoining one than the usual interval; but they soon appeared to perceive their error, and corrected it by giving to the comb a gradual curvature, so as to resume the ordinary distance[a].

In another instance, in which various irregularities had taken place in the form of the combs, the bees, in prolonging one of them, had, contrary to their usual custom, begun two separate and distant continuations, which in approaching instead of joining would have interfered with each other, had not the bees, apparently foreseeing the difficulty, gradually bent their edges so as to make them join with such exactness that they could afterwards continue them conjointly[b].

In constructing their combs, bees, as you have been before told, in my letter on the habitations of insects, form the first range of cells—that by which the comb is attached to the top of the hive—of a different shape from the rest. Each cell instead of being hexagonal is pentagonal, having the fifth broadest side fixed to the top of the hive, whence the comb is much more securely cemented to that part, than if the first range of cells had been of the ordinary construction. For some time after their fabrication, the combs remain in this state; but at a certain period the bees attack the first range of cells as if in fury, gnaw away the sides without touching the lozenge-shaped bottoms; and having mixed the wax with propolis, they form a cement well known to the

[a] Huber, ii. 239. [b] Ibid. ii. 240.

ancients under the names of *Mitys* or *Commosis* and *Pissoceros*, which they substitute in the place of the removed sides of the cells, forming of it thick and massive walls and heavy and shapeless pillars, which they introduce between the comb and the top of the hive so as to agglutinate them firmly together. Huber, who first in modern times witnessed this remarkable modification of the architecture of bees, observed, that not only are they careful not to touch the bottoms of the cells, but that they do not remove at once the cells on both sides of the comb, which in that case might fall down; but they work alternately, first on one side and then on the other, replacing the demolished cells as they proceed, with mitys, which firmly fixes the comb to its support.

The object of this substitution of mitys for wax seems clear. While the combs are new and only partially filled with honey, the first range of cells, originally established as the base and the guide for the pyramidal bottoms of the subsequent ones, serves as a sufficient support for them. But when they contain a store of several pounds, the bees seem to foresee the danger of such a weight proving too heavy for the thin waxen walls by which the combs are suspended, and providently hasten to substitute for them thicker walls, and pillars of a more compact and viscid material.

But their foresight does not stop here. When they have sufficient wax, they make their combs of such a breadth as to extend to the sides of the hive, to which they cement them by constructions approaching more or less to the shape of cells. But when a scarcity of wax happens before they have been able to give to their combs the requisite diameter, a large vacant space is left

between the edges of these combs, which are only fixed by their upper part, and the sides of the hive; and they might be pulled down by the weight of the honey, did not the bees ensure their stability by introducing large irregular masses of wax between their edges and the sides of the hive.—A striking instance of this art of securing their magazines occurred to Huber. A comb, not having been originally well fastened to the top of his glass hive, fell down during the winter amongst the other combs, preserving, however, its parallelism with them. The bees could not fill up the space between its upper edge and the top of the hive, because they never construct combs of old wax, and they had not then an opportunity of procuring new: at a more favourable season they would not have hesitated to build a new comb upon the old one; but it being inexpedient at that period to expend their provision of honey in the elaboration of wax, they provided for the stability of the fallen comb by another process. They furnished themselves with wax from the other combs, by gnawing away the rims of the cells more elongated than the rest, and then betook themselves in crowds, some upon the edges of the fallen comb, others between its sides and those of the adjoining combs; and there securely fixed it, by constructing several *ties* of different shapes between it and the glass of the hive; some were pillars, others buttresses, and others beams artfully disposed and adapted to the localities of the surfaces joined. Nor did they content themselves with repairing the accidents which their masonry had experienced; they provided against those which might happen, and appeared to profit by the warning given by the fall of one of the combs to consolidate the others and pre-

vent a second accident of the same nature. These last had not been displaced, and appeared solidly attached by their base; whence Huber was not a little surprised to see the bees strengthen their principal points of connexion by making them much thicker than before with old wax, and forming numerous ties and braces to unite them more closely to each other and to the walls of their habitation.—What was still more extraordinary, all this happened in the middle of January, at a period when the bees ordinarily cluster at the top of the hive, and do not engage in labours of this kind[a].

You will admit, I think, that these proofs of the resources of the architectural instinct of bees are truly admirable. If, in the case of the substitution of mitys for the first range of waxen cells, this procedure *invariably* took place in *every* bee-hive at a *fixed* period—when, for example, the combs are two-thirds filled with honey—it would be less surprising: but there is nothing of this invariable character about it. It does not, as Huber expressly informs us[b], occur at any marked and regular period, but appears to depend on several circumstances not always combined. Sometimes the bees content themselves with bordering the sides of the upper cells with propolis alone, without altering their form or giving them greater thickness. And it is not less remarkable that, from the instances last cited, it appears that they are not confined to one kind of cement for strengthening and supporting their combs, but avail themselves of propolis, wax, or a mixture of both, as circumstances direct.

Not to weary you with examples of the modifications

[a] Ibid. ii. 280. [b] Huber, ii. 284, note *.

of instinct we are considering, I shall introduce but three more:—the first, of the mode in which bees extend the dimensions of an old comb; the second, of that which they adopt in constructing the male cells and connecting them with the smaller cells of workers; and the last, of the plan pursued by them when it becomes necessary to bend their combs.

You must have observed that a comb newly made becomes gradually thinner at its edges, the cells there, on each side, progressively decreasing in length: but in time these marginal cells, as they are wanted for the purposes of the hive, are elongated to the depth of the rest. Now suppose bees, from an augmentation of the size of their hive, to have occasion to extend their combs either in length or breadth, the process which they adopt is this: They gnaw away the tops of the marginal cells until the combs have resumed their original lenticular form, and then construct upon their edges the pyramidal lozenge-shaped bottoms of cells, upon which the hexagonal sides are subsequently raised, as in their operation of cell-building. This course of proceeding is invariable: they never extend a comb in any direction whatever, without having first made its edges thinner, diminishing its thickness in a portion sufficiently large to leave no angular projection.—Huber observes, and with reason, in relating this surprising law which obliges bees partially to demolish the cells situated upon the edges of the combs, that it deserves a more close examination than he found himself competent to give it: for, if we may to a certain point form a conception of the instinct which leads these animals to employ their art of building cells, yet how can we conceive of that which in particular cir-

cumstances forces them to act in an opposite direction, and determines them to *demolish* what they have so laboriously constructed[a]?

Drones, or male bees, are more bulky than the workers; and you have been told, in speaking of the habitations of insects, that the cells which bees construct for rearing the larvæ of the former, are larger than those destined for the education of the larvæ of the latter. The diameter of the cells of drones is always $3\frac{1}{3}$ lines (or twelfths of an inch); that of those of workers $2\frac{2}{5}$ lines: and these dimensions are so constant in their ordinary cells, that some authors have thought they might be adopted as an universal and invariable scale of measure, which would have the great recommendation of being every where at hand, and at all events would be preferable to our *barley-corns*. Several ranges of male cells, sometimes from thirty to forty, are usually found in each comb, generally situated about the middle. Now as these cells are not isolated, but form a part of the entire comb, corresponding on its two faces—by what art is it that the bees unite hexagonal cells of a small, with others of a larger diameter, without leaving any void spaces, and without destroying the uniformity and regularity of the comb? This problem would puzzle an ordinary artist, but is easily solved by the resources of the instinct of our little workmen.

When they are desirous of constructing the cells of males below those of workers, they form several ranges of intermediate or transition cells, of which the diameter augments progressively, until they have reached that

[a] Huber, ii. 228.

range where the male cells commence: and in the same manner, when they wish to revert to the modelling of the cells of workers, they pass by a gradually decreasing gradation to the ordinary diameter of the cells of this class.—We commonly meet with three or four ranges of intermediate cells before coming to those of males; the first ranges of which participate in some measure in the irregularity of the former.

But it is upon the construction of the *bottoms* of the intermediate ranges of cells that this variation of their architecture chiefly hinges. The bottoms of the regular cells of bees are, as you are aware, composed of *three* equal-sized rhomboidal pieces; and the base of a cell on one side of the comb is composed of portions of the bases of *three* cells on the other: but the bottoms of the intermediate cells in question (though their orifices are perfectly hexagonal) are composed of *four* pieces, of which two are hexagonal and two rhomboidal; and each, instead of corresponding with three cells on the opposite side, corresponds with *four*. The size and the shape of the four pieces composing the bottom, vary; and these intermediate cells, a little larger than the third part of the three opposite cells, comprise in their contour a portion of the bottom of a fourth cell. Just below the last range of cells with regular pyramidal bottoms, are found cells with bottoms of four pieces, of which three are very large, and one very small, and this last is a rhomb. The two rhombs of the transition cells are separated by a considerable interval; but the two hexagonal pieces are adjacent and perfectly alike. A cell lower, we perceive that the two rhombs of the bottom are not so unequal: the contour of the cell has included a greater portion of the

opposite fourth cell. Lastly, we find cells in pretty considerable number, of which the bottom is composed of four pieces perfectly regular—namely, two elongated hexagons and two equal rhombs, but smaller than those of the pyramidal bottoms. In proportion as we remove our view from the cells with regular tetrahedral bottoms, whether in descending or from right to left, we see that the subsequent cells resume their ordinary form; that is to say, that one of their rhombs is gradually lessened until it finally disappears entirely; and the pyramidal form re-exhibits itself, but on a larger scale than in the cells at the top of the comb. This regularity is maintained in a great number of ranges, namely, those consisting of male cells; afterwards the cells diminish in size, and we again remark the tetrahedral bottoms just described, until the cells have once more resumed the proper diameter of those of workers.

It is, then, by encroaching in a small degree upon the cells of the other face of the comb, that bees at length succeed in giving greater dimensions to their cells; and the graduation of the transition cells being reciprocal on the two faces of the comb, it follows that on both sides each hexagonal contour corresponds with four cells.—When the bees have arrived at any degree of this mode of operating, they can stop there and continue to employ it in several consecutive ranges of cells: but it is to the intermediate degree that they appear to confine themselves for the longest period, and we then find a great number of cells of which the bottoms of four pieces are perfectly regular. They might, then, construct the whole comb on this plan, if their object were not to revert to

the pyramidal form with which they set out.—In building the male cells, the bees begin their foundation with a block or mass of wax thicker and higher than that employed for the cells of workers, without which it would be impracticable for them to preserve the same order and symmetry in working on a larger scale.

Irregularities (to use the language of Huber, from whom the above details are abstracted,) have often been observed in the cells of bees. Reaumur, Bonnet and other naturalists cite them as so many examples of imperfections. What would have been their astonishment if they had been aware that part of these anomalies are *calculated;* that there exists as it were a moveable harmony in the mechanism by which the cells are composed! If, in consequence of the imperfection of their organs or of their instruments, bees occasionally constructed some of their cells unequal, or of parts badly put together, it would still manifest some talent to be able to repair these defects, and to compensate one irregularity by another: but it is far more astonishing that they know how to quit their ordinary routine when circumstances require that they should build male cells; that they should be instructed to vary the dimensions and the shape of each piece so as to return to a regular order; and that, after having constructed thirty or forty ranges of male cells, they again leave the regular order on which these were formed, and arrive by successive diminutions at the point from which they set out. How should these insects be able to extricate themselves from such a difficulty—from such a complicated structure? how pass from the little to the great, from a regular plan to an irregular one,

and again resume the former? These are questions which no known system can explain[a].

Here again, as observed in a former instance, the wonder would be less, if *every* comb contained a *certain* number of transition and of male cells, constantly situated in *one* and the *same* part of it: but this is far from being the case. The event which alone, at whatever period it may happen, seems to determine the bees to construct male cells, is the oviposition of the queen. So long as she continues to lay the eggs of workers not a male cell is founded; but as soon as she is about to lay male eggs, the workers seem aware of it, and you then see them form their cells irregularly, impart to them by degrees a greater diameter, and at length prepare suitable ranges of cradles for all the male race[b].—You must perceive how absurd it would be to refer this astonishing variation of instinct to any mere change in the *sensations* of the bees; and to what far-fetched and gratuitous suppositions we must be reduced, if we adopt any such explanation. We can but refer it to an instinct of which we know nothing; and so referring it, can we help exclaiming with Huber, "Such is the grandeur of the views and of the means of ordaining wisdom, that it is not by a minute exactness that she marches to her end, but proceeds from irregularity to irregularity, compensating one by another: the admeasurements are made on high, the apparent errors appreciated by a divine geometry; and order often results from partial diversity. This is not the first instance which science has presented to us of preordained irregularities which astonish our ig-

[a] Huber, ii. 221-226. 244-247.   [b] Ibid. ii. 226.

norance, and are the admiration of the most enlightened minds: So true it is, that the more we investigate the general as well as particular laws of this vast system, the more perfection does it present[a]."

It is observed by M. P. Huber, in his appendix to the account of his father's discoveries relative to the architecture of bees, that in general the form of the prisms or tubes of the cells is more essential than that of their bottoms, since the tetrahedral-bottomed transition cells, and even those cells which being built immediately upon wood or glass, were entirely without bottoms, still preserved their usual shape of hexagonal prisms. But a remarkable experiment of the elder Huber shows that bees can alter even the form of their cells when circumstances require it, and that in a way which one would not have expected.

Having placed in front of a comb which the bees were constructing, a slip of glass, they seemed immediately aware that it would be very difficult to attach it to so slippery a surface: and instead of continuing the comb in a straight line, they *bent it at a right angle*, so as to extend beyond the slip of glass, and ultimately fixed it to an adjoining part of the wood-work of the hive which the glass did not cover. This deviation, if the comb had been a mere simple and uniform mass of wax, would have evinced no small ingenuity; but you will bear in mind that a comb consists on each side, or face, of cells having between them bottoms in common: and if you take a comb, and having softened the wax by heat, endeavour to bend it in any part at a right angle, you will

[a] Huber, ii. 230.

then comprehend the difficulties which our little architects had to encounter. The resources of their instinct, however, were adequate to the emergency. They made the cells on the *convex* side of the bent part of the comb much *larger*, and those on the *concave* side much *smaller* than usual; the former having three or four times the diameter of the latter. But this was not all. As the bottoms of the small and large cells were as usual common to both, the cells were not regular prisms, but the small ones considerably wider at the bottom than at the top, and conversely in the large ones!—What conception can we form of so wonderful a flexibility of instinct? How, as Huber asks, can we comprehend the mode in which such a crowd of labourers, occupied at the same time on the edge of the comb, could agree to give to it the same curvature from one extremity to the other; or how they could arrange together to construct on one face cells so small, while on the other they imparted to them such enlarged dimensions?—And how can we feel adequate astonishment that they should have the art of making cells of such different sizes correspond[a]?

After this long but I flatter myself not wholly uninteresting enumeration, you will scarcely hesitate to admit that insects, and of these the bee pre-eminently, are endowed with a much more exquisite and flexible instinct than the larger animals. But you may be here led to ask, Can all this be referred to instinct? Is not this pliability to circumstances—this surprising adaptation of means for accomplishing an end—rather the result of *reason?*

[a] Huber, ii. 219—.

You will not doubt my allowing the appositeness of this question, when I frankly tell you, that so strikingly do many of the preceding facts seem at first view the effect of reason, that in my original sketch of the letter you are now reading, I had arranged them as instances of this faculty. But mature consideration has convinced me (though I confess the subject has great difficulties) that this view was fallacious; and that though some circumstances connected with these facts may, as I shall hereafter show, be referable to reason, the facts themselves can only be consistently explained by regarding them as I have here done, as examples of variations of particular instincts:—and this on two accounts.

In the first place, these variations, however singular, are *limited* in their extent: all bees are, and have always been, able to avail themselves of a certain number, but not to increase that number. Bees cemented their combs when becoming heavy, to the top of the hive, with mitys, in the time of Aristotle and Pliny as they do now; and there is every reason to believe that then, as now, they occasionally varied their procedures, by securing them with wax or with propolis only, either added to the upper range of cells, or disposed in braces and ties to the adjoining combs. But if in thus proceeding they were guided by reason, why not under certain circumstances adopt *other* modes of strengthening their combs? Why not, when wax and propolis are scarce, employ *mud*, which they might see the martin avail herself of so successfully? Or why should it not come into the head of some hoary denizen of the hive, that a little of the *mortar* with which his careful master plasters the crevices between his habitation and its stand, might answer the end of mitys?

"Si seulement ils élevoient une fois des câbanes quarrées," (says Bonnet when speaking as to what faculty the works of the beaver are to be referred,) "mais ce sont éternellement des câbanes rondes ou ovales[a]:"—and so we might say of the phenomena in question:—Show us but *one* instance of bees having substituted mud or mortar for mitys, pissoceros, or propolis, or wooden props for waxen ties, and there could be no doubt of their being here guided by reason. But since no such instance is on record; since they are still confined to the same limits—however surprising the range of these limits—as they were two thousand years ago; and since the bees emerged from their pupæ but a few hours before, will set themselves as adroitly to work and pursue their operations as scientifically as their brethren, who can boast the experience of a long life of twelve months duration;—we must still regard these actions as variations of instinct.

In the second place, no degree of reason that we can with any share of probability attribute to bees, could be competent to the performance of labours so complicated as those we have been considering, and which, if the result of reason, would involve the most extensive and varied knowledge in the agents. Suppose a man to have attained by long practice the art of modelling wax into a congeries of uniform hexagonal cells, with pyramidal bottoms composed each of three rhombs, resembling the cells of workers among bees. Let him now be set to make a congeries of similar but larger cells (answering to the male cells), and unite these with the former by other hexagonal cells, so that there should be no disruption in the continuity or regularity of the whole assem-

[a] *Œuvres*, ix. 159.

blage, and no vacant intervals or patching at the junctions either of the tubes or the bottoms of the cells;—and you would have set him no very easy task—a task, in short, which it may be doubted if he would satisfactorily perform in a twelvemonth, though gifted with a clear head and a competent store of geometrical knowledge, and which, if destitute of these requisites, it may be safely asserted that he would never perform at all. How then can we imagine it possible that this difficult problem, and others of a similar kind, can be so completely and exactly solved by animals of which some are not two days old, others not a week, and probably none a year? The conclusion is irresistible—it is not *reason* but *instinct* that is their guide.

The second head under which I proposed contrasting the instincts of insects with those of the larger animals, was that of their *number* in the same individual.—In the latter this is for the most part very limited, not exceeding (if we omit those common to almost all animated beings) eight or ten distinct instincts. Thus in the common duck, one instinct leads it at its birth from the egg to rush to the water; another to seek its proper food; a third to pair with its mate; a fourth to form a nest; a fifth to sit upon its eggs till hatched; a sixth to assist the young ducklings in extricating themselves from the shell; and a seventh to defend them when in danger until able to provide for themselves: and it would not be easy, as far as my knowledge extends, to add many more distinct instinctive actions to the enumeration, or to adduce many species of the superior classes of animals, endowed with a greater number.

But how vastly more manifold are the instincts of the

majority of insects! It is not necessary to insist upon those differences which take place in the same insect in its different states, leading it to select one kind of food in the larva, and another in the perfect state; to defend itself in one mode in the former, and in another in the latter, &c.—because, however remarkable these variations, they may be referred with great plausibility to those striking changes in the organic structure of the animal, which occur at the two periods of its existence. It is to the number of instincts observable in the same individual of many insects in their perfect state that I now confine myself; and as the most striking example of the whole I shall select the hive-bee,—begging you to bear in mind that I do not mean to include those exhibited by the queen, the drones, or even those of the workers, termed by Huber *cirières* (wax-makers); but only to enumerate those presented by that portion of the workers, termed by Huber *nourrices* or *petites abeilles* (nurses), upon whom, as you have been before told[a], with the exception of making wax, laying the foundation of the cells, and collecting honey for being stored, the principal labours of the hive devolve. It will be these individuals alone that I shall understand by the term *bees*, under the present head: and though the other inhabitants of the hive may occasionally concur in some of their actions and labours, yet it is obvious that so many as are those in which *they* distinctly take part, so many instincts must we regard them as endowed with.

To begin, then, with the formation of the colony:—By one instinct bees are directed to send out scouts previously to their swarming in search of a suitable abode[b];

[a] Vol. I. 4th Ed. 490. [b] See above, p. 189.

and by another, to rush out of the hive after the queen that leads forth the swarm, and follow wherever she bends her course. Having taken possession of their new abode, whether of their own selection or prepared for them by the hand of man, a third instinct teaches them to cleanse it from all impurities [a]; a fourth to collect propolis; and with it to stop up every crevice except the entrance; a fifth to ventilate the hive for preserving the purity of the air; and a sixth to keep a constant guard at the door [b].

In constructing the houses and streets of their new city, or the cells and combs, there are probably several distinct instincts exercised; but not to leave room for objection, I shall regard them as the result of one only: yet the operations of polishing the interior of the cells, and soldering their angles and orifices with propolis, which are sometimes not undertaken for weeks after the cells are built [c]; and the obscure but still more curious one of varnishing them with the yellow tinge observable in old combs;—seem clearly referable to at least two distinct instincts. The varnishing process is so little connected with that of building, that, though it takes place in some combs in three or four days, it does not in others for several months, though both are equally employed for the same uses [d]. Huber ascertained by accurate experiment that this tinge is not owing to the heat of the hives; to any vapours in the air which they include; to any emanations from the wax or honey; nor to the deposition of this last in the cells; but he inclines to think it is occasioned by a yellow matter which the bees seem

[a] Huber, ii. 102. [b] Ibid. i. 186. ii. 412.
[c] Huber: ii. 264—. Vol. I. 4th Ed. 500. [d] Huber, ii. 274.

to detach from their mandibles, and to apply to the surface which they are varnishing, by repeated strokes of these organs and of the fore feet [a].

In their out-of-door operations several distinct instincts are concerned. By one they are led to extract honey from the nectaries of flowers; by another to collect pollen after a process involving very complicated manipulations, and requiring a singular apparatus of brushes and baskets; and that must surely be considered a third, which so remarkably and beneficially restricts each gathering to the same plant [b]. It is clearly a distinct instinct which inspires bees with such dread of rain, that even if a cloud pass before the sun, they return to the hive in the greatest haste [c]; and that seems to me not less so, which teaches them to find their way back to their home after the most distant and intricate wanderings. When bees have found the direction in which their hive lies, Huber says they fly to it with an extreme rapidity, and as straight as a ball from a musket [d]: and if their hives were always in open situations, one might suppose, as Huber seems inclined to think, that it is by their sight they are conducted to them. But hives are frequently found in small gardens embowered in wood, and in the midst of villages surrounded and interspersed with trees and buildings, so as to make it impossible that they can be seen from a distance. If you had been with me in 1815, in the famous Pays de Waes in Flanders—where the country is a perfect flat, and the inhabitants so enamoured either of the beauty or profit of trees, that their fields, which are rarely above three acres in extent, are

[a] Huber, ii. 275—.
[b] See above, p. 182.
[c] Huber, i. 356.
[d] Ibid. ii. 367.

constantly surrounded with a double row, making the whole district one vast wood—you would have pitied the poor bees if reduced to depend on their own eye-sight for retracing the road homeward. In vain during my stay at St. Nicholas I sallied out at every outlet to try to gain some idea of the extent and form of the town. Trees—trees—trees—still met me, and intercepted the view in every direction; and I defy any inhabitant bee of this rural metropolis, after once quitting its hive, ever to gain a glimpse of it again until nearly perpendicularly over it. The bees, therefore, of the Pays de Waes, and consequently all other bees, must be led to their abodes by instinct, as certainly as it is instinct that directs the migrations of birds or of fishes, or domestic quadrupeds to find out their homes from inconceivable distances[a].—When they have reached the hive, another instinct leads them to regurgitate into the extended proboscis of their hungry companions who have been occupied at home, a portion of the honey collected in the fields; and another directs them to unload their legs of the masses of pollen, and to store it in the cells for future use.

[a] The following striking anecdote of this last species of instinct in an animal not famed for sagacity, was related to me by Lieutenant Alderson, (royal engineers,) who was personally acquainted with the facts.—In March 1816 an ass, the property of Captain Dundas, R.N., then at Malta, was shipped on board the Ister frigate, Captain Forrest, bound from Gibraltar for that island. The vessel having struck on some sands off the Point de Gat, at some distance from the shore, the ass was thrown overboard to give it a chance of swimming to land—a poor one, for the sea was running so high that a boat which left the ship was lost. A few days afterwards, however, when the gates of Gibraltar were opened in the morning, the ass presented himself for admittance, and proceeded to the stable of Mr. Weeks, a merchant, which he had formerly occupied, to the no small surprise

Several distinct instincts, again, are called into action in the important business of feeding the young brood. One teaches them to swallow pollen, not to satisfy the calls of hunger, but that it may undergo in their stomach an elaboration fitting it for the food of the grubs; and another to regurgitate it when duly concocted, and to administer it to their charge, proportioning the supply to the age and condition of the recipients. A third informs them when the young grubs have attained their full growth, and directs them to cover their cells with a waxen lid, convex in the male cells, but nearly flat in those of workers; and by a fourth, as soon as the young bees have burst into day, they are impelled to clean out the deserted tenements and to make them ready for new occupants.

Numerous as are the instincts I have already enumerated, the list must yet include those connected with that mysterious principle which binds the working bees of a hive to their queen:—the singular imprisonment in which they retain the young queens that are to lead off a swarm, until their wings be sufficiently expanded to

of this gentleman, who imagined that from some accident the animal had never been shipped on board the Ister. On the return of this vessel to repair, the mystery was explained; and it turned out that Valiante (so the ass was called) had not only swam safely to shore, but, without guide, compass, or travelling map, had found his way from Point de Gat to Gibraltar, a distance of more than two hundred miles, which he had never traversed before, through a mountainous and intricate country, intersected by streams, and in so short a period that he could not have made one false turn. His not having been stopped on the road was attributed to the circumstance of his having been formerly used to whip criminals upon, which was indicated to the peasants, who have a superstitious horror of such asses, by the holes in his ears, to which the persons flogged were tied.

enable them to fly the moment they are at liberty, gradually paring away the waxen wall that confines them to their cell to an extreme thinness, and only suffering it to be broken down at the precise moment required;—the attention with which, in these circumstances, they feed the imprisoned queen by frequently putting honey upon her proboscis, protruded from a small orifice in the lid of her cell;—the watchfulness with which, when at the period of swarming more queens than one are required, they place a guard over the cells of those undisclosed, to preserve them from the jealous fury of their excluded rivals;—the exquisite calculation with which they invariably release the *oldest* queens the first from their confinement;—the singular love of monarchical dominion, by which, when two queens in other circumstances are produced, they are led to impel them to combat until one is destroyed;—the ardent devotion which binds them to the fate and fortunes of the survivor;—the distraction which they manifest at her loss, and their resolute determination not to accept of any stranger until an interval has elapsed sufficiently long to allow of no chance of the return of their rightful sovereign;—and (to omit a further enumeration) the obedience which in the utmost noise and confusion they show to her well-known hum.

I have now instanced at least thirty distinct instincts with which every individual of the nurses amongst the working-bees is endowed: and if to the account be added their care to carry from the hive the dead bodies of any of the community; their pertinacity in their battles, in directing their sting at those parts only of the bodies of their adversaries which are penetrable by it; their

annual autumnal murder of the drones, &c. &c.—it is certain that this number might be very considerably increased, perhaps doubled.

At the first view you will be inclined to suspect some fallacy in this enumeration, and that this variety of actions ought to be referred rather to some general principle, capable of accommodating itself to different circumstances, than to so many different kinds of instinct. But to what principle? Not to reason, the faculty to which we assign this power of varying accommodation. All the actions above adduced come strictly under the description of instinctive actions, being all performed by every generation of bees since the creation of the world, and as perfectly a day or two after their birth as at any subsequent period. And as the very essence of instinct consists in the determinate character of the actions to which it gives birth, it is clear that every distinctly different action must be referred to a distinct instinct. Few will dispute that the instinct which leads a duck to resort to the water is a different instinct from that which leads her to sit upon her eggs; for the hen though endowed with one is not with the other. In fact, they are as distinct and unconnected as the senses of sight and smell; and it appears to me that it would be as contrary to philosophical accuracy of language, in the former case to call the two instincts modifications of each other, as in the latter so to designate the two senses; and as we say that a deaf and blind man has fewer senses than other men, so (strictly) we ought not to speak of instinct as one faculty (though to avoid circumlocution I have myself often employed this common mode of expression), or say that one insect has a greater or less share of instinct than

another, but more or fewer *instincts*.—That it is not always easy to determine what actions are to be referred to a distinct instinct and what to a modification of an instinct, I am very ready to admit; but this is no solid ground for regarding all instincts as modifications of some one principle. It is often equally difficult to fix the limits between instinct and reason; but we are not on this account justified in deeming them the same.

This multitude of instincts in the same individual, becomes more wonderful when considered in another point of view. Were they constantly to follow each other in regular sequence, so that each bee necessarily first began to build cells, then to collect honey, next pollen, and so on, we might plausibly enough refer them to some change in the sensations of the animal, caused by alterations in the structure and gradual development of its organs, in the same way as on similar principles we explain the sexual instincts of the superior tribes. But it is certain that no such consecutive series prevails. The different instincts of the bee are called into action in an order regulated solely by the needs of the society. If combs be wanted, no bee collects honey for storing until they are provided[a]: and if, when constructed, any accident injure or destroy them, every labour is suspended until the mischief is repaired or new ones substituted[b]. When the crevices round the hive are effectually secured with propolis, the instinct directing the collection of this substance lies dormant: but transfer the bees to a new hive which shall require a new luting, and it is instantly re-excited. But these instances are

[a] Huber, ii. 64. [b] Ibid. ii. 138.

superfluous. Every one knows that at the same moment of time the citizens of a hive are employed in the most varied and opposite operations. Some are collecting pollen; others are in search of honey; some busied at home in the first construction of the cells; others in giving them their last polish; others in ventilating the hive; others again in feeding the young brood and the like.

Now, how are we to account for this regularity of procedure—this undeviating accuracy with which the precise instinct wanted is excited—this total absence of all confusion in the employment by each inhabitant of the hive, of that particular instinct out of so many which the good of the community requires? No thinking man ever witnesses the complexness and yet regularity and efficiency of a great establishment, such as the Bank of England, or the Post-office, without marvelling that even human reason can put together with so little friction and such slight deviations from correctness, machines whose wheels are composed not of wood and iron, but of fickle mortals of a thousand different inclinations, powers, and capacities. But if such establishments be surprising even with reason for their prime mover, how much more so is a hive of bees whose proceedings are guided by their instincts alone! We can conceive that the sensations of hunger experienced on awaking in the morning should excite into action their instinct of gathering honey. But all are hungry: yet all do not rush out in search of flowers. What *sensation* is it that *detains* a portion of the hive at home, unmindful of the gnawings of an empty stomach, busied in domestic arrangements, until the return of their roving companions? Of those that fly

abroad, what conception can we form of the cause which, while one set is gathering honey or pollen, leads another company to load their legs with pellets of propolis? Are we to say that the instinct of the former is excited by one sensation, that of the latter by another? But why should one sensation predominate in one set of bees, while another takes the lead in a second?—or how is it that these different instincts are called up precisely in the degree which the actual and changing state of things in the hive requires?—Of those which remain at home, what is it that determines in one party the instinct of building cells to prevail; in another that of ventilating the hive; in a third that of feeding the young brood? For my own part, I confess that the more I reflect on this subject, and contrast the diversity of the means with the regularity and uniformity of the end, the more I am lost in astonishment. The effects of instinct seem even more wonderful than those of reason, in the same manner as the consentaneous movements of a mighty and divided army, which, though under the command of twenty generals and from the most distant quarters, should meet at the assigned spot at the very hour fixed upon, would be more surprising than the steam-moved operations, however complex, of one of Boulton's mints.

For the sake of distinctness and compression, I have confined myself in considering the number of the instincts of individual insects to a single species, the bee; but if the history of other societies of these animals—wasps, ants, &c. detailed in my former letters, be duly weighed, it will be seen that they furnish examples of the variety in question fully as striking. These corroborating proofs I shall leave to your own inference, and

proceed to the third head, under which I proposed to consider the instincts of insects—that of their extaordinary development.

The development of some of the instincts of the larger animals, such as those of sex, is well known to depend upon their age and the peculiar state of the bodily organs; and to this, as before observed, the succession of different instincts in the same insect, in its larva and perfect state, is closely analogous. But what I have now in view is that *extraordinary development* of instinct, which is dependent not upon the age or any change in the organization of the animal, but upon external events—which in individuals of the *same* species, age, and structure, in some circumstances slumbers unmoved, but may in others be excited to the most singular and unlooked-for action. In illustrating this property of instinct, which, as far as I am aware, is not known to occur in any of the larger animals, I shall confine myself as before to the hive-bee; the only insect, indeed, in which its existence has been satisfactorily ascertained, though it is highly probable that other species living in societies may exhibit the same phenomenon.

Several of the facts occurring in the history of bees might be referred to this head; but I shall here advert only to the treatment of the drones by the workers under different circumstances, and to the operations of the latter consequent upon the irretrievable loss of the queen—facts which have been before stated to you, but to the principal features of which my present argument makes it necessary that I should again direct your attention.

If a hive of bees be this year in possession of a queen

duly fertilized, and consequently sure the next season of a succession of males, all the drones, as I have before stated[a], towards the approach of winter are massacred by the workers with the most unrelenting ferocity. To this seemingly cruel course they are doubtless impelled by an imperious instinct; and as it is regularly followed in every hive thus circumstanced, it would seem at the first view to be an impulse as intimately connected with the organization and very existence of the workers, and as incapable of change, as that which leads them to build cells or to store up honey. But this is far from being the case. However certain the doom of the drones this autumn, if the hive be furnished with a duly-fertilized queen, their undisturbed existence over the winter is equally sure if the hive have lost its sovereign, or her impregnation have been so retarded as to make a succession of males in the spring doubtful. In such a hive the workers do not destroy a single drone, though the hottest persecution rages in all the hives around them.

Now, how are we to explain this difference of conduct? Are we to suppose that the bees know and reason upon this alteration in the circumstances of their community—that they infer the possibility of their entire extinction if the whole male stock were destroyed when without a queen—and that thus influenced by a wise policy they restrain the fury they would otherwise have exercised? This would be at once to make them not only gifted with reason, but endowed with a power of looking before and after, and a command over the strongest natural propensities, superior to what could be expected in a similar

[a] See above, p. 173—

case even from a society of men; and is obviously unwarrantable. The only probable supposition is, clearly, that a new instinct is developed suited to the extraordinary situation in which the community stands, leading them now to regard with kindness the drones, for whom otherwise they would have felt the most violent aversion.

In this instance, indeed, it would perhaps be more strictly correct to say (which, however, is equally wonderful) that the old instinct was extinguished; but in the case of the loss of a queen, to which I am next to advert, which is followed by positive operations, the extraordinary development of a new and peculiar instinct is indisputable.

In a hive which no untoward event has deprived of its queen, the workers take no other active steps in the education of her successors—those of which one is to occupy her place when she has flown off at the head of a new swarm in spring—than to prepare a certain number of cells of extraordinary capacity for their reception while in the egg, and to feed them when become grubs with a peculiar food until they have attained maturity. This, therefore, is their ordinary instinct; and it may happen that the workers of a hive may have no necessity for a long series of successive generations to exercise any other. But suppose them to lose their queen. Far from sinking into that inactive despair which was formerly attributed to them, after the commotion which the rapidly-circulated news of their calamity gave birth to has subsided, they betake themselves with an alacrity from which man when under misfortune might deign to take a lesson, to the active reparation of their loss. Several ordinary cells,

as was before related at large[a], are without delay pulled down, and converted into a variable number of royal cells capacious enough for the education of one or more queen-grubs selected out of the unhoused working grubs—which in this pressing emergency are mercilessly sacrificed—and fed with the appropriate royal food to maturity. Thus sure of once more acquiring a head, the hive return to their ordinary labours, and in about sixteen days one or more queens are produced; one of which, after being indebted to fortune for an elevation as singular as that of Catherine the First of Russia, steps into day and assumes the reins of state.

To this remarkable deviation from the usual procedures of the community, the observations above made in the case of the drones must be applied. We cannot account for it by conceiving the working bees to be acquainted with the end which their operations have in view. If we suppose them to *know* that the queen and working-grubs are originally the same, and that to convert one of the latter into the former it is only necessary to transfer it to an apartment sufficiently spacious and to feed it with a peculiar food, we confer upon them a depth of reason to which Prometheus, when he made his clay man, had no pretensions—an original discovery, in short, to which man has but just attained after some thousand years of painful research, having escaped all the observers of bees from Aristomachus to Swammerdam and Reaumur of modern times. We have no other alternative, then, but to refer this phenomenon to the extraordinary

[a] See above, p. 130—.

development of a new instinct suited for the exigency, however incomprehensible to us the manner of its excitement may appear.

II. Such, then, are the exquisiteness, the number, and the extraordinary development of the instincts of insects. But is instinct the *sole* guide of their actions? Are they in every case the blind agents of irresistible impulse? These queries, I have already hinted, cannot in my opinion be replied to in the affirmative; and I now proceed to show, that though instinct is the chief guide of insects, they are endowed also with no inconsiderable portion of *reason*.

Some share of reason is denied by few philosophers of the present day to the larger animals. But its existence has not generally (except by those who reject instinct altogether) been recognised in insects; probably on the ground that, as the proportions of reason and of instinct seem to co-exist in an inverse ratio, the former might be expected to be extinct in a class in which the latter is found in such perfection. This rule, however, though it may hold good in man, whose instincts are so few and imperfect, and whose reason is so pre-eminent, is far from being confirmed by an extended survey of the classes of animals generally. Many quadrupeds, birds, and fishes, with instincts apparently not very acute, do not seem to have their place supplied by a proportionably superior share of reason: and insects, as I think the facts I have to adduce will prove, though ranking so low in the scale of creation, seem to enjoy as great a degree of reason as many animals of the superior classes, yet in combination with instincts much more numerous and exquisite.

I must premise, however, that in so perplexed and intricate a field, I am sensible how necessary it is to tread with caution. A far greater collection of facts must be made, and the science of metaphysics generally be placed on a more solid foundation than it now can boast, before we can pretend to decide, in numerous cases, which of the actions of insects are to be deemed purely instinctive, and which the result of reason. What I advance, therefore, on this head, I wish to be regarded rather as conjectures, that, after the best consideration I am able to give to a subject so much beyond my depth, seem to me plausible, than as certainties to which I require your implicit assent.

That reason has nothing to do with the major part of the actions of insects is clear, as I have before observed, from the determinateness and perfection of these actions, and from their being performed independently of instruction and experience. A young bee (I must once more repeat) betakes itself to the complex operation of building cells, with as much skill as the oldest of its compatriots. We cannot suppose that it has any *knowledge* of the purposes for which the cells are destined; or of the effects that will result from its feeding the young larvæ, and the like. And if an individual bee be thus destitute of the very materials of reasoning as to its main operations, so must the society in general.

Nor in those remarkable deviations and accommodations to circumstances, instanced under a former head, can we, for considerations there assigned, suppose insects to be influenced by reason. These deviations are still limited in number, and involve acts far too complex and recondite to spring from any process of ratiocina-

tion in an animal whose term of life does not exceed two years.

It does not follow, however, that reason may not have a part in inducing some of these last-mentioned actions, though the actions themselves are purely instinctive. I do not pretend to explain in what way or degree they are combined; but certainly some of the facts do not seem to admit of explanation, except on this supposition. Thus, in the instance above cited from Huber, in which the bees bent a comb at right angles in order to avoid a slip of glass, the remarkable variations in the form of the cells can only, as I have there said, be referred to instinct. Yet the original determination to avoid the glass seems, as Huber himself observes, to indicate something more than instinct, since glass is not a substance against which Nature can be supposed to have forewarned bees, there being nothing in hollow trees (their natural abodes) resembling it either in polish or substance: and what was most striking in their operations was, that they did not wait until they had reached the surface of the glass before changing the direction of the comb, but adopted this variation at a considerable distance, as though they foresaw the inconveniences which might result from another mode of construction[a].—However difficult it may be to form a clear conception of this union of instinct and reason in the same operation, or to define precisely the limits of each, instances of these *mixed* actions are sufficiently common among animals to leave little doubt of the fact. It is instinct which leads a greyhound to pursue a hare; but it must be reason that directs "an *old* greyhound to

[a] Huber, ii. 219.

trust the more fatiguing part of the chase to the younger, and to place himself so as to meet the hare in her doubles[a]."

As another instance of these mixed actions in which both reason and instinct seem concerned, but the former more decidedly, may be cited the account which Huber gives of the manner in which the bees of some of his neighbours protected themselves against the attacks of the death's-head moth (*Sphinx Atropos*), laid before you in a former letter[b], by so closing the entrance of the hive with walls, arcades, casements, and bastions, built of a mixture of wax and propolis, that these insidious marauders could no longer intrude themselves.

We can scarcely attribute these elaborate fortifications to reason simply; for it appears that bees have recourse to a similar defensive expedient when attacked even by other bees; and the means employed seem too subtle and too well adapted to the end to be the result of this faculty in a bee.

But on the other hand, if it be most probable that in this instance instinct was chiefly concerned, if we impartially consider the facts, it seems impossible to deny that reason had some share in the operations. Pure instinct would have taught the bees to fortify themselves on the *first* attack. If the occupants of a hive had been taken unawares by these gigantic aggressors one night, on the second, at least, the entrance should have been barricadoed. But it appears clear from the statement of Huber, that it was not until the hives had been repeatedly attacked and robbed of nearly their whole stock of

[a] Hume's *Essay on the Reason of Animals*. [b] See above, p. 267.

honey, that the bees betook themselves to the plan so successfully adopted for the security of their remaining treasures; so that reason taught by experience, seems to have called into action their dormant instinct[a].

If it be thus probable that reason has some influence upon the actions of insects, which must be mainly regarded as instinctive, the existence of this faculty is still more evident in numerous traits of their history where instinct is little if at all concerned. An insect is taught by its instincts the most unerring means to the attainment of certain ends; but these ends, as I have already had occasion more than once to remark, are limited in number, and such only as are called for by its wants in a state of nature. We cannot reasonably suppose insects to be gifted with instincts adapted for occasions that are never likely to happen. If therefore we find them, in these extraordinary and improbable emergencies, still availing themselves of the means apparently best calculated for ensuring their object;—and if in addition they seem in some cases to gain knowledge by experience; if they can communicate information to each other; and if they are endowed with memory—it appears impossible to deny that they are possessed of reason.—I shall now produce facts in proof of each of these positions; not by any means all that might be adduced, but a few of the most striking that occur to me.

First, then, insects often in cases not likely to be provided for by instinct, adopt means evidently designed for effecting their object.

[a] Huber, ii. 289—.

A certain degree of warmth is necessary to hatch a hen's eggs, and we give her little credit for reason in sitting upon them for this purpose. But if any one had ever seen a hen make her nest in a heap of fermenting dung, among the bark of a hot-bed, or in the vicinity of a baker's oven, where, the heat being as well adapted as the stoves of the Egyptians to bring her chickens into life, she left off the habit of her race, and saved herself the trouble of sitting upon them,—we should certainly pronounce her a *reasoning* hen: and if this hen had chanced to be that very one figured and so elaborately described by Professor Fischer, with *the profile of an old woman*[a], a Hindoo metaphysician at least could not doubt of her body, however hen-like, being in truth directed in its operations by the soul of some quondam amateur of poultry-breeding. Now societies of ants have more than once exhibited a deviation from their usual instinct, which to me seems quite as extraordinary and as indicative of reason as would be that supposed in a hen. A certain degree of warmth is required for the exclusion and rearing of their eggs, larvæ and pupæ; and in their ordinary abodes, as you have been already told[b], they undergo great daily labour in removing their charge to different parts of the nest, as its temperature is affected by the presence or absence of the sun. But Reaumur, in refuting the common notion of ants being injurious to bees, tells us that societies of the former often saved themselves all this trouble, by establishing their colonies be-

[a] See Fischer's *Beschreibung eines Huhns mit menschenähnlichem Profile*, 8vo, St. Petersburg 1816, and a translation in Thomson's *Annals of Phil.* viii. 241.

[b] Vol. I. 4th Ed. 364.

tween the exterior wooden shutters and panes of his glass hives, where, owing to the latter substance being a tolerably good conductor of heat, their progeny was at *all times*, and without any necessity of changing their situation, in a constant, equable, and sufficient temperature[a]. Bonnet observed the same fact. He found that a society of ants had piled up their young to the height of several inches, between the flannel-lined case of his glass hives and the glass. When disturbed they ran away with them, but always replaced them[b].

I am persuaded that after duly considering these facts, you will agree with me that it is impossible consistently to refer them to instinct, or to account for them without supposing some stray ant, that had insinuated herself into this tropical crevice, first to have been struck with the *thought* of what a prodigious saving of labour and anxiety would occur to her compatriots by establishing their society here;—that she had communicated her *ideas* to them;—and that they had resolved upon an emigration to this new-discovered country—this Madeira of ants—whose genial clime presented advantages which no other situation could offer. Neither instinct, nor any conceivable modification of instinct, could have taught the ants to avail themselves of a good fortune which but for the invention of glass hives would never have offered itself to a generation of these insects since the creation; for there is nothing analogous in nature to the constant and equable warmth of such a situation, the heat of any accidental mass of fermenting materials soon ceasing, and no heat being given out from a society of bees when lodged

[a] Reaum. v. 709. [b] *Œuvres*, ii. 416.

in a hollow tree, their natural residence. The conclusion, then, seems irresistible, that reason must have been their guide, inducing a departure from their natural instinct as extraordinary as would be that of a hen which should lay her eggs in a hot-bed, and cease to sit upon them.

The adaptation of means to an end not likely to have been provided for by instinct, is equally obvious in the ingenious mode by which a nest of humble-bees propped up their tottering comb, the particulars of which having before mentioned to you [a], I need not here repeat.

There is perhaps no surer criterion of reason than, after having tried one mode of accomplishing a purpose, adopting another more likely to succeed. Insects are able to stand this test. A bee which Huber watched while soldering the angles of a cell with propolis, detached a thread of this material with which she entered the cell. Instinct would have taught her to separate it of the exact length required; but after applying it to the angle of the cell, she found it too long, and cut off a portion so as to fit it to her purpose [b].

This is a very simple instance; but one such fact is as decisive in proof of reason as a thousand more complex, and of such there is no lack. Dr. Darwin (whose authority in the present case depending not on hearsay, but his own observation, may be here taken,) informs us, that walking one day in his garden he perceived a wasp upon the gravel walk with a large fly nearly as big as itself which it had caught. Kneeling down he distinctly saw it cut off the head and abdomen, and then taking up with its feet the trunk or middle portion of the body to which

[a] Vol. I. 4th Ed. 379. [b] Huber, ii. 268.

the wings remained attached, fly away. But a breeze of wind acting upon the wings of the fly turned round the wasp with its burthen, and impeded its progress. Upon this it alighted again on the gravel walk, deliberately sawed off first one wing and then the other; and having thus removed the cause of its embarrassment, flew off with its booty[a]. Could any process of ratiocination be more perfect? "Something acts upon the wings of this fly and impedes my flight. If I wish to reach my nest quickly, I must get rid of them—to effect which, the shortest way will be to alight again and cut them off." These reflections, or others of similar import, must be supposed to have passed through the mind of the wasp, or its actions are altogether inexplicable. Instinct might have taught it to cut off the wings of *all* flies, previously to flying away with them. But here it first attempted to fly with the wings on,—was impeded by a certain cause,—discovered what this cause was,—and alighted to remove it. The chain of evidence seems perfect in proof that nothing but reason could have been its prompter.

An analogous though less striking fact is mentioned by Reaumur on the authority of M. Cossigny, who witnessed it in the Isle of France where the Spheges are accustomed to bury the bódies of cockroaches along with their eggs for provision for their young. He sometimes saw one of these Spheges attempt to drag after it into its hole a dead cockroach, which was too big to be made to enter by all its efforts. After several ineffectual trials the Sphex came out, cut off its elytra and some of its legs, and thus reduced in compass drew in its prey without difficulty[b].

[a] *Zoonomia*, i. 183.

[b] Reaum. vi. 283.

Under this head I shall mention but one fact more.—A friend of Gleditsch the observer of the singular economy of the burying beetle (*Necrophorus Vespillo*) related in a former letter[a], being desirous of drying a dead toad, fixed it to the top of a piece of wood which he stuck into the ground. But a short time afterwards, he found that a body of these indefatigable little sextons had circumvented him in spite of his precautions. Not being able to reach the toad, they had undermined the base of the stick until it fell, and then buried both stick and toad[b].

In the second place, insects gain knowledge from *experience*, which would be impossible if they were not gifted with some portion of reason. In proof of their thus profiting, I shall select from the numerous facts that might be brought forward, two only, one of which has been already slightly adverted to[c].

M. P. Huber, in his valuable paper in the sixth volume of the *Linnean Transactions*[d], states that he has seen large humble-bees, when unable from the size of their head and thorax to reach to the bottom of the long tubes of the flowers of beans, go directly to the calyx, pierce it as well as the tube with the exterior horny parts of their proboscis, and then insert their proboscis itself into the orifice and abstract the honey. They thus flew from flower to flower, piercing the tubes from without, and sucking the nectar, while smaller humble-bees or those with a longer proboscis entered in at the top of the corolla. Now from this statement it seems evident, that the larger bees did not pierce the bottoms of the flowers until

[a] Vol. I. 4th Ed. 350.
[b] Gleditsch *Physic. Bot. Œcon. Abhandl.* iii. 220.
[c] See above, p. 118. [d] p. 222.

they had ascertained by trial that they could not reach the nectar from the top; but that having once ascertained by experience that the flowers of beans are too strait to admit them, they then, without further attempts in the ordinary way, pierced the bottoms of *all* the flowers which they wished to rifle of their sweets.—M. Aubert du Petit-Thouars observed that humble-bees and *Xylocopa violacea* gained access in a similar manner to the nectar of *Antirrhinum Linaria* and *majus*, and *Mirabilis Jalappa*; as do the common bees of the Isle of France to that of *Canna indica*[a]; and I have myself more than once noticed holes at the base of the long nectaries of *Aquilegia vulgaris*, which I attribute to the same agency.

My second fact is supplied by the same ants, whose sagacious choice of the vicinity of Reaumur's glass hives for their colony has been just related to you. He tells us that of these ants, of which there were such swarms on the outside of the hive, not a single one was ever perceived within; and infers that, as they are such lovers of honey, and there was no difficulty in finding crevices to enter in at, they were kept without, solely from fear of the consequences[b]. Whence arose this fear? We have no ground for supposing ants endowed with any instinctive dread of bees; and Reaumur tells us, that when he happened to leave in his garden, hives of which the bees had died, the ants then never failed to enter them and regale themselves with the honey. It seems reasonable, therefore, to attribute it to experience. Some of the ants no doubt had tried to enter the peopled as they did the

[a] *Nouveau Bulletin des Sciences*, i. 45. [b] Reaum. v. 709.

empty hive, but had been punished for their presumption, and the dear-bought lesson was not lost on the rest of the community.

Insects, in the third place, are able mutually to *communicate* and *receive information*, which, in whatever way effected, would be impracticable if they were devoid of reason. Under this head it is only necessary to refer you to the endless facts in proof, furnished by almost every page of my letters on the history of ants and of the hive-bee. I shall therefore but detain you for a moment with an additional anecdote or two, especially with one respecting the former tribe, which is valuable from the celebrity of the relater.

Dr. Franklin was of opinion that ants could communicate their ideas to each other; in proof of which he related to Kalm, the Swedish traveller, the following fact. Having placed a pot containing treacle in a closet infested with ants, these insects found their way into it, and were feasting very heartily when he discovered them. He then shook them out and suspended the pot by a string from the ceiling. By chance one ant remained, which, after eating its fill, with some difficulty found its way up the string, and thence reaching the ceiling, escaped by the wall to its nest. In less than half an hour a great company of ants sallied out of their hole, climbed the ceiling, crept along the string into the pot, and began to eat again. This they continued until the treacle was all consumed, one swarm running up the string while another passed down[a]. It seems indisputable that the one ant had in

[a] Kalm's *Travels in North America*, i. 239.

this instance conveyed news of the booty to his comrades, who would not otherwise have at once directed their steps in a body to the only accessible route.

A German artist, a man of strict veracity, states that in his journey through Italy he was an eye-witness to the following occurrence. He observed a species of *Scarabæus* busily engaged in making, for the reception of its egg, a pellet of dung, which when finished it rolled to the summit of a small hillock, and repeatedly suffered to tumble down its side, apparently for the sake of consolidating it by the earth which each time adhered to it. During this process the pellet unluckily fell into an adjoining hole, out of which all the efforts of the beetle to extricate it were in vain. After several ineffectual trials, the insect repaired to an adjoining heap of dung, and soon returned with three of his companions. All four now applied their united strength to the pellet, and at length succeeded in pushing it out; which being done, the three assistant beetles left the spot and returned to their own quarters [a].

Lastly, insects are endowed with *memory*, which (at least in connexion with the purposes to which it is subservient) implies some degree of reason also; and their historian may exclaim with the poet who has so well sung the pleasures of this faculty,

> Hail, MEMORY, hail! thy universal reign
> Guards the least link of Being's glorious chain.

In the elegant lines in which this couplet occurs [b],

[a] Illiger *Mag.* i. 488.

[b] "Hark! the bee winds her small but mellow horn,
Blithe to salute the sunny smile of morn. O'er

which were pointed out to me by my friend Dr. Alderson of Hull, Mr. Rogers supposes the bee to be conducted to its hive by retracing the scents of the various flowers which it has visited: but this idea is more poetical than accurate, bees, as before observed[a], flying straight to their hives from great distances. Here, as I have more than once had occasion to remark in similar instances, we have to regret the want of more correct entomological information in the poet, who might have employed with as much effect, the real fact of bees distinguishing their own hives out of numbers near them, when conducted to the spot by instinct. This recognition of home seems clearly the result of memory; and it is remarkable that bees appear to recollect their own hive rather from its situation, than from any observations on the hive itself[b]: just as a man is guided to his house from his memory of its position relative to other

---

O'er thymy downs she bends her busy course,
And many a stream allures her to its source.
'Tis noon, 'tis night. That eye so finely wrought,
Beyond the search of sense, the soar of thought,
Now vainly asks the scenes she left behind;
Its orb so full, its vision so confined!
Who guides the patient pilgrim to her cell?
Who bids her soul with conscious triumph swell?
With conscious truth retrace the mazy clue
Of varied scents that charm'd her as she flew?
Hail, MEMORY, hail! thy universal reign
Guards the least link of Being's glorious chain."

[a] See above, p. 188 and 501.

[b] If a hive be removed out of its ordinary position, the first day after this removal, the bees do not fly to a distance without having visited all the neighbouring objects. The queen does the same thing when flying into the air for fecundation. Huber, *Recherches sur les Fourmis*, 100.

buildings or objects, without its being necessary for him even to cast a look at it. If, after quitting my house in a morning, it were to be lifted out of its site in the street by enchantment, and replaced by another with a similar entrance, I should probably, even in the day time, enter it, without being struck by the change; and bees, if during their absence their old hive be taken away, and a similar one set in its place, enter this last, and if it be provided with brood comb contentedly take up their abode in it, never troubling themselves to inquire what has become of the identical habitation which they left in the morning, and with the inhabitants of which, if it be removed to fifty paces distance, they never resume their connexion [a].

If, pursuing my illustration, you should object that no man would thus contentedly sit down in a new house without searching after the old one, you must bear in mind that I am not aiming to show that bees have as precise a memory as ours, but only that they are endowed with some portion of this faculty, which I think the above fact proves. Should you view it in a different light, you will not deny the force of others that have already been stated in the course of our correspondence: such as the mutual greetings of ants of the same society when brought together after a separation of four months [b]; and the return of a party of bees in spring to a window where in the preceding autumn they had regaled on honey, though none of this substance had been again placed there [c].

[a] See the account of the mode in which the Favignanais increase the number of their hives by thus dividing them. Huber, ii. 459.

[b] See above, p. 66. [c] Ibid. p. 202.

But the most striking fact evincing the memory of these last-mentioned insects has been communicated to me by my intelligent friend Mr. William Stickney, of Ridgemont, Holderness. About twenty years ago, a swarm from one of this gentleman's hives took possession of an opening beneath the tiles of his house, whence, after remaining a few hours, they were dislodged and hived. For many subsequent years, when the hives descended from this stock were about to swarm, a considerable party of scouts were observed for a few days before to be reconnoitring about the old hole under the tiles; and Mr. Stickney is persuaded, that if suffered they would have established themselves there. He is certain that for eight years successively the descendants of the very stock that first took possession of the hole frequented it as above stated, and *not* those of any other swarms; having constantly noticed them, and ascertained that they were bees from the original hive by powdering them while about the tiles with yellow ochre, and watching their return. And even at the present time there are still seen every swarming season about the tiles, bees, which Mr. Stickney has no doubt are descendants from the original stock.

Had Dr. Darwin been acquainted with this fact, he would have adduced it as proving that insects can convey traditionary information from one generation to another; and at the first glance the circumstance of the descendants of the same stock retaining a knowledge of the same fact for twenty years, during which period there must have been as many generations of bees, would seem to warrant the inference. But as it is more probable that the party of surveying scouts of the first ge-

neration was the next year accompanied by others of a second, who in like manner conducted their brethren of the third, and these last again others of the fourth generation, and so on,—I draw no other conclusion from it than that bees are endowed with memory, which I think it proves most satisfactorily.

I am, &c.

END OF THE SECOND VOLUME.

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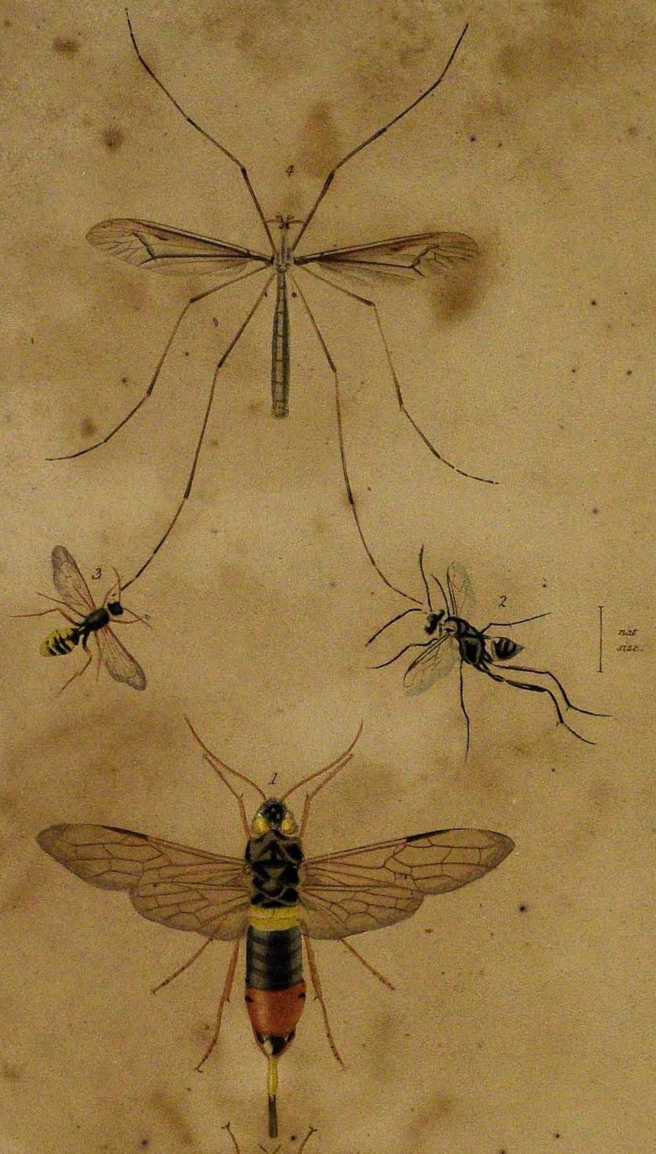
ALERE FLAMMAM.

Plate IV.



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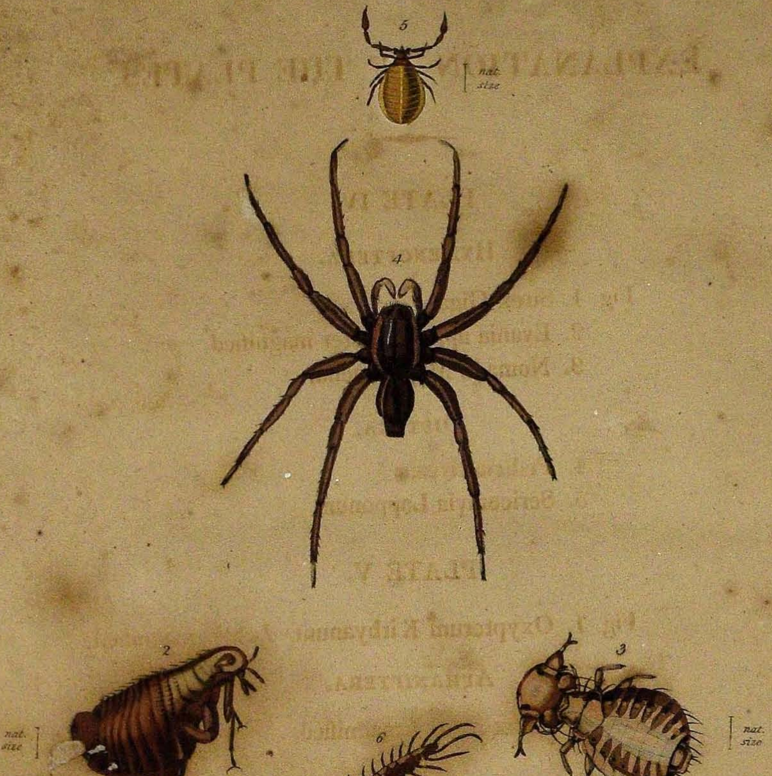

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EXPLANATION OF THE PLATES.

PLATE IV.

Hymenoptera.

Fig. 1. Sirex Gigas.
2. Evania appendigaster magnified.
3. Nomada Marshamella.

Diptera.

4. Pedicia rivosa.
5. Sericomyia Lapponum.

PLATE V.

Fig. 1. Oxypterum Kirbyanum. *Leach*, magnified.

Aphaniptera.

2. Pulex irritans magnified.

Aptera.

3. Ricinus Pavonis magnified.
4. Aranea marginata. *Donovan*.
5. Chelifer cancroides magnified.
6. Scolopendra forficata.

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